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A Common Source of Wealth

THERE was a man once who found a gold mine in a sand bank. He worked the bank for sand and sold the sand for gold.

There are gold mines all about us—in the clouds of exhaust steam and in the streams of condensate pouring out of the plants where power is generated

It takes 1,125 B.t.u. to make a pound of 150-pound steam out of water at the temperature corresponding to a 28-inch vacuum.

The most perfect heat engine that we can conceive could convert only about 32 per cent of this heat into power, working between those limits.

A steam engine or turbine with a Rankine efficiency as high as 70 per cent can convert only about 20 per cent of it.

This exhaust steam is as good as any other steam for heating and for many processes, and it pays to run an engine even under a considerable back pressure, to get exhaust steam of sufficient temperature for such purposes.

The engine will take more steam per horsepower, but if a considerable proportion of the exhaust can be usefully employed, the combined cost of meeting the power, heating and process demands will be much reduced.

Notwithstanding all that has been said and written upon the subject, it is still not uncommon to see prime movers run condensing, pouring the most of the heat that has been put into them into the river, while coal is burned under other boilers to make steam at low pressure for heating and process work.

Some persons seem to think that the amount of heat required to make steam is proportional to the pressure.

It takes 1,195 B.t.u. to make a pound of 150-pound steam and 1,160 to make a pound of 10-pound steam.

It is vastly cheaper to put in the extra 35 B.t.u. while you are about it, make the steam all at 150 pounds, utilize the drop from that pressure and temperature to the desired exhaust temperature for making light and power, and heat with as much of the exhaust as is needed.

A turbine can be bled at any level in the heat drop, taking off steam of any desired temperature and letting the rest complete its work in the lower stages and go to the condenser.

A compound engine can be bled at the receiver; a single-cylinder run one-legged and systems have been suggested for bleeding this type by opening a port into the heating system at a predetermined point in the stroke, with a check valve to prevent back-flow when the cylinder pressure falls below that bled into.

The principal difficulty is the lack of synchronism between the power and heating loads. The sand bank was valuable only because it was near a market. It may not pay to run an inefficient non-condensing engine all the time to get heat for a few hours a day or a few months in the year, but it can be put down as undeniable that where there is a steady demand for a large proportion of the heat that a heat engine rejects, the power can be generated almost as a byproduct.

F. R. Low

Largest Single-Cylinder, Single-Flow Reaction Turbine Yet Built

ONE pound of steam at 300 lb. 250 deg. superheat has a volume of about 2 cu.ft. When it has expanded to 29 in. vacuum, it will occupy over 500 cu.ft., and at 29½ more than 1,000 cu.ft., notwithstanding the fact that about one-fifth has here been condensed to water.

The problem in a large turbine is therefore to get rid of great volumes of steam; to provide enough large blades at the exhaust end to pass steam efficiently. Centrifugal force limits the blade lengths and diameters to those which will not exceed safe stresses in the materials available. Blades of extreme length involve an excessive difference between base velocity and tip velocity, and though designed for good efficiency at the average velocity, the poor efficiency realized near the ends will adversely effect the over-all efficiency.

In seeking to meet the continued demand for large units, the efforts of turbine designers have been directed to providing vane area for the complete expansion of the increased volume of the steam and its discharge to the condenser at a moderate velocity. One school has adhered to the single-cylinder direct-flow type, meeting the necessarily high peripheral velocities by refinements in material, design and workmanship and with a reduced factor of safety. Another school has attacked the problem by dividing the exhaust and providing two sets of exhaust blading, one at each end of the cylinder, making what is called the double-flow type; or by dividing the turbine into several turbine-generator units, with a high-speed high-pressure unit exhausting into one or two lower-speed, low-pressure units. In the latter "cross-compound" type, high speed in the high-pressure unit is made possible by the relatively small high-pressure blades. This means that more work can be obtained efficiently per row of blades, since the work done per blade is approximately proportional to the square of the blade speed, and therefore less blade area is required. The slower low-pressure units are better suited to long vanes at the exhaust on account of less centrifugal force at the required blade speed, and the double-flow principle is easily applied. The cross-compound unit possesses additional advantages of flexibility and reliability, but involves considerably greater first cost.

Both of these expedients involve some disadvantages. The double-flow type must have its two, often widely separated, discharge flanges flexibly attached to the condenser. The heavy rubber or copper expansion joints necessary are expensive and require special attention. The cross-compound unit requires extra foundations, floor space and an additional generator.

A method of solving the problem devised by Karl Bauman, of England, has been adopted by the Westinghouse Electric & Manufacturing Co., for the 35,000-kw. units which it is building for the Springdale Station of the West Penn Power Company.

Suppose that the largest single-flow reaction turbine, as limited by the safe length of the last row of blades, under ordinary design conditions carried 10,000 kw. at the most economical load and it is desired to increase this to 15,000 kw. at practically the same economy.

The high-pressure blades can easily be made longer so as to pass the greater volume of steam at about the same velocity, but the last row of low-pressure vanes is already of greatest safe length and cannot be extended.

Fig. 1 shows schematically such a reaction turbine, the blades in solid lines representing those for the largest single-flow machine of the usual design and dotted extensions suggesting added length for increased capacity, the proportions being only approximate. The last blade, row 10, is already of the greatest safe length and cannot be extended to *A* when the capacity is increased.

FIRST of the new-type single-flow turbines undertaken by the Westinghouse company. Large capacity at moderate peripheral speeds and conservative stresses made possible by the use of the Bauman system of blading; symmetrically expanding steam path eliminates eddies. Provision is made for bleeding at four points, and several new constructional features are incorporated.

To pass the additional steam volume through the existing blade area in row 10 would mean increased steam velocity. Steam would then be discharged into the condenser at a high rate of speed, representing insufficient expansion and therefore lost energy that should have been used in driving the rotor.

The Bauman method of obtaining sufficient exhaust-blade area is illustrated in Fig. 2, where steam is divided into two belts at the last blade rows by means of partitions in the blades. The outer path allows expansion through ample blade area so as to do work efficiently.

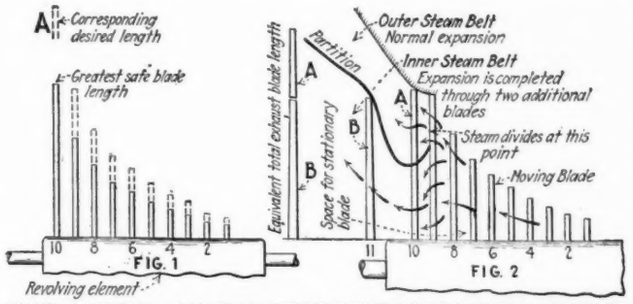
Steam of the inner path is bypassed through rows 10, expanding only a small amount, doing little work. The expansion of this steam, however, is completed by adding a row of stationary and moving blades, rows 11, which contain sufficient area to use the remaining available energy efficiently and discharge into the condenser with the least practical amount of velocity remaining. The combined length of exhaust blades *A* and *B* is sufficient to give the desired total exhaust-blade area without an increase in blade length.

Fig. 3 shows in more detail the construction of rows 10 of blades, as well as added rows 11. The outer belt expands normally and efficiently through sections *A* and *B*.

The inner belt separated by partitions from the outer, is bypassed through *C* stationary row 10 with practically no expansion; this section acts merely as a port. Moving section *D* expands steam to some extent, which helps drive the reaction vanes of the rotor.

There is still a comparatively great amount of energy remaining in the steam, and this is efficiently used by

adding two rows of blades, *E* stationary and *F* revolving, which are proportioned to expand to condenser pressure with ample exhaust area. By adding one row each of revolving and stationary blades, the capacity will be increased 60 per cent above the original. In adding two rows of each type vanes and arranging an additional steam belt, the increase is 120 per cent and with three additional rows, 170 per cent.



FIGS. 1 AND 2—BAUMAN PRINCIPLE INCREASES CAPACITY OF SINGLE-FLOW TURBINE

Fig. 1—Diagram of largest single-flow turbine with dotted blade extension representing additional length for increasing capacity. The last blades at row 10 are already at greatest safe length and cannot be increased to corresponding desired height at *A*. Fig. 2—The Bauman principle is to divide the steam into two belts and to add an extra row of stationary and of moving blades. The outer belt expands completely and efficiently in row 10 of the original blading. The inner belt passes row 10 with little expansion and completes expansion in the added rows 11 of stationary and moving blades.

Another means of increasing blade area due to Bauman is by greatly enlarging the blade width at the rotor, as shown in Fig. 4. Long blades must have a comparatively heavy cross-section at the rotor, as shown at *A*, which limits the width of the steam passage *P* between blades. The same cross-sectional area used in the blades at *B* with greater width *W*, permits thinner structure and consequently a wider steam passage *Q* between blades. Three steam passages to exhaust are provided in the 35,000-kw. units for Springdale.

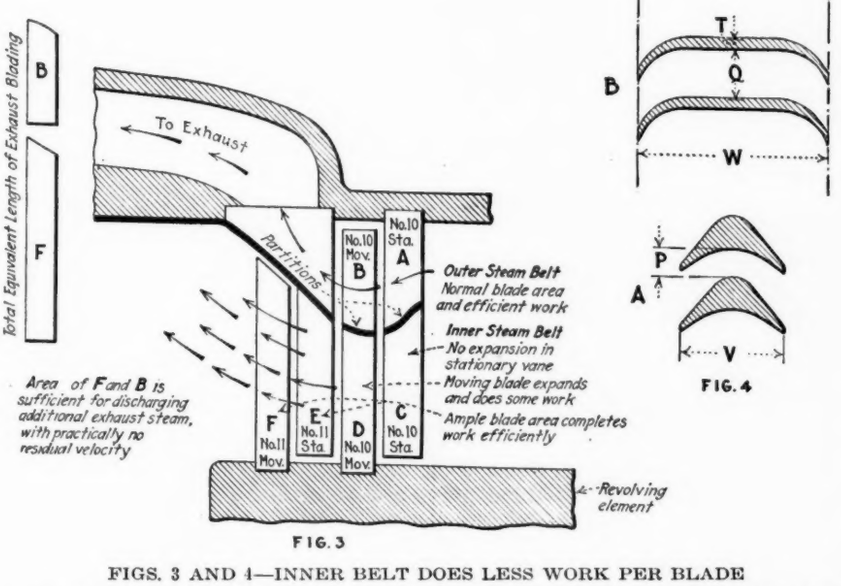
In Fig. 5 long blades with extended bases are indicated at rows 20 and 21. Moving vane 21 has a negative taper, in regard to thickness, or, in other words, becomes thicker up to the barrier, or partition. After this partition, however, the thickness becomes less up to the tip and the width remains constant. The Bauman construction, as first described, begins at row 22, Fig. 5. Two rows of blades are here added, giving three openings to exhaust. Expansion is restricted in the inner paths so as to give less work per blade. The steam passage made by the first 20 rows of reaction blading is what has come to be known as the conical type, forming a symmetrical divergent annular nozzle through which the expanding steam may flow smoothly and without the eddies induced by the abrupt changes of diameter of the stepped drum employed in older construction.

Steam enters the first blade ring *B* at 120 lb. absolute, assuming that the most economical load, 26,000 kw., is being carried. Provision is made for extracting steam at this point, for feed-water heating, but this is not utilized at the present time. The blade rings, instead of being supported loosely in rectangular grooves in the casing, are keyed into position, so that any tendency to close in on the rotor due to abnormal conditions is restrained by the resistance of the outer cylinder. This ring contains eight stationary rows of blades which expand steam for supplying eight moving blades, finally discharging steam at 50 lb. absolute into the second group of blades.

Provision which may be utilized in the future is also made for extracting steam between these rings. The second ring *C*, which also contains eight rows of blades, discharges at 12.9 lb. absolute and approximately 5 lb. per sec. is extracted for use in the second of the two feed-water heaters operating in series.

The third blade ring *D* supports three stationary reaction rows of blades of the usual construction, while row No. 20 of stationary blades is of the Bauman type. Steam is here extracted at 3.2 lb. absolute for low-temperature heater. This contains a barrier dividing the steam into two parts. That in the upper path, which here begins, travels the tip sections of three moving blades before part of it is admitted to the exhaust at row 22.

The peculiarly shaped barrier in stationary row 22 gives an indication of the expansion in the upper path, which must deliver steam from moving row 23 at 29 in. vacuum, with practically all the available energy extracted from the steam. Inefficient blades would discharge steam into the condenser with considerable speed, representing wasted energy.



FIGS. 3 AND 4—INNER BELT DOES LESS WORK PER BLADE

Fig. 3—Indicates partitions made by forming a filler piece on each side of a blade, and the relative work done in blade rows of each belt. Total exhaust blade area of *F* and *B* is ample for complete expansion. Fig. 4—How blade areas may be increased by using thinner and wider blades. Width of steam passage *P* at the base of the usual type of large blade is enlarged to width *Q* by increasing blade width from *V* to *W* while using same cross-sectional area.

Stationary and revolving rows 23 exhaust at their tip sections, while expansion is restricted in the path next to the rotor with specially designed blade shapes, allowing steam to pass with little loss through to the final blades where sufficient area is provided for complete expansion.

Conditions are such in this unit that expansion takes place in the last moving vane, so that it operates on the

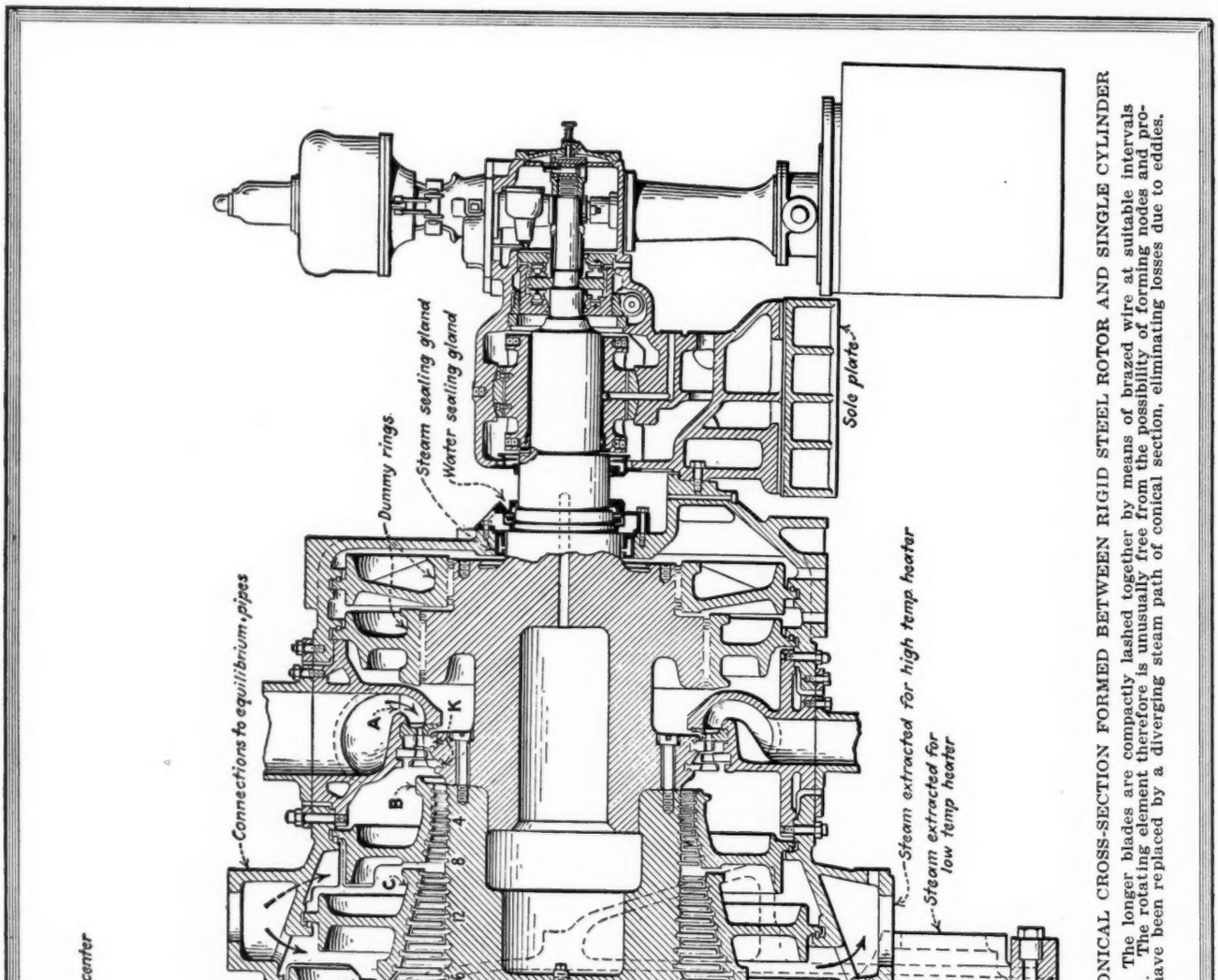


FIG. 5—BAUMAN TYPE BLADING CONTAINED IN STEAM PATH OF CONICAL CROSS-SECTION FORMED BETWEEN RIGID STEEL ROTOR AND SINGLE CYLINDER

Rigidity of the steel rotor greatly reduces the possibility of vibration. The longer blades are compactly lashed together by means of brazed wire at suitable intervals and are tapered from broad shanks to the tips, further increasing stiffness. The rotating element therefore is unusually free from the possibility of forming nodes and producing sympathetic vibration. The cylindrical blade passages or barrels have been replaced by a diverging steam path of conical section, eliminating losses due to eddies.

reaction principle. The Bauman blades are carefully designed with varying shapes to suit change of velocity from the shank to the tip of blade, and to control expansion properly. These are drop-forged, with barriers integral in each vane, and interlocking. Lashing wires assist in maintaining a rigid blade structure.

A Forged Steel Rotor

The substantial steel rotor represents immense strength and rigidity, illustrating one of the advantages of the reaction type of low-pressure element over the disk construction of the usual impulse design.

A pressed fit, which is reinforced by bolts, unites the high-pressure with the low-pressure end. The adaptability of such a rotor to high temperatures is apparent when it is considered that the joint occurs where very little difference of temperature is produced, and the higher temperature, if any, is effective on the interior member of this pressed fit which would tend to hold this tight in case it became warmer than the recessed member of the fit. Such a condition, however, would not be expected to occur in practice to any appreciable extent. Balancing holes are drilled at each end.

Two dummy rings, as shown on Fig. 5, are provided. Equalizer pipes connect with suitable pressure zones in the turbine. The form of rotating and stationary packing has recently been adopted and is illustrated in Fig. 6. The rotating element is finished in a number of conical surfaces, while the stationary member contains thin brass annular rings or fins which project very close to the rotating body. This construction has

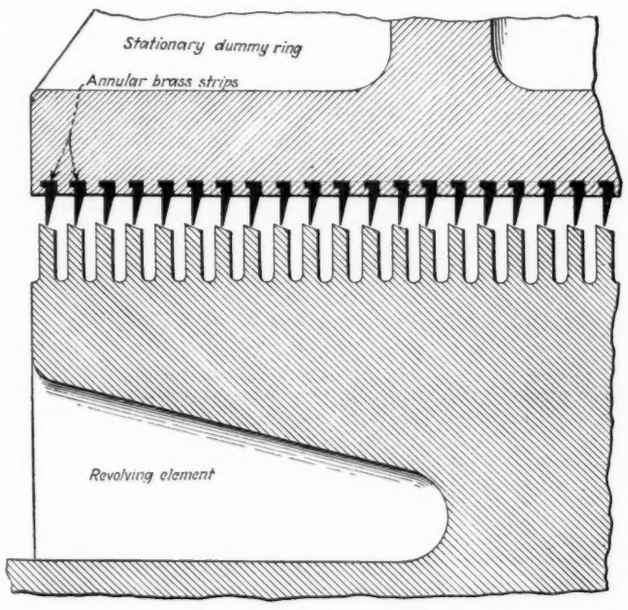


FIG. 6—ANNULAR BRASS STATIONARY STRIPS FORM A CLOSE CLEARANCE TO REVOLVING CONICAL SURFACES OF THE DUMMY PISTON

proved satisfactory in 500 marine-type turbines and is being rapidly adapted to land practice. Clearances are adjusted by moving the rotating body in an axial direction. It can be seen that the clearance is made smaller by moving the rotating body to the right in Fig. 6 and larger if the movement is toward the left. If rubbing should occur, the conical elements will radiate heat much more rapidly than the old type of ring, of cylindrical shape, and it will only be a question of pushing the thin fin to one side, so there is not the liability of the stripping that would occur in case thin fins were in both the moving and stationary elements. The stationary blades only are subject to stripping. A close fit between the stationary and revolving element is obtained by grinding these together when the machine is at speed. The rotor is moved toward the right so as to close up the clearances until rubbing between stationary and moving elements actually takes place,

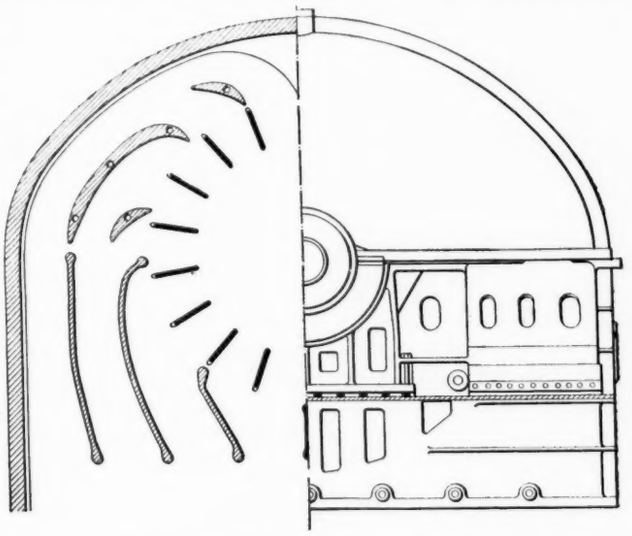


FIG. 7—EIGHT MAIN EXHAUST CHAMBERS EACH CONTAINING THREE SUBDIVISIONS, ARE DESIGNED ON STREAM-LINE PRINCIPLES

and the thin fins are ground to an exact fit to the dummy. After this the rotor is brought to the left for the desired amount of clearance.

The general construction of the turbine cylinder as viewed from the outside in relation to the rest of the unit is shown in Fig. 8. Another change from usual practice is that the valve chest is here placed above the turbine cylinder, containing the primary, secondary and tertiary valves.

The steam chest is attached rigidly to the turbine at the primary steam inlet, and flexible connecting pipes supply the secondary and tertiary nozzle chambers.

Another feature is the provision for pressure in the oil cylinders for both a closing and an opening direction, instead of using spring pressure alone for the closing power. Steam may be extracted at *B*, *C*, *D* and *E*, Fig. 5, for the purpose of heating the feed water. The points at *D* and *E* are used at the present time for the heaters.

Referring to Fig. 5, it will be seen that two sealing glands are provided at each end of the turbine, that next to the atmosphere being a water gland, while the other is a steam labyrinth gland. The latter is useful in starting up, when it is desired to obtain a low vacuum without turning the machine over or else while turning at a low speed, as the water seal does not become effective until an appreciable degree of speed is reached. The water-sealing gland, however, is most useful in preventing leakage of the steam seal from reaching the atmosphere and in assisting to keep the shaft cool where it enters the bearings. This combination is in many ways most desirable.

The general arrangement of the two surface or closed heaters, the valve chest placed on top of the cylinder, and the condenser suspended from the exhaust head, are shown in Fig. 8. The complete unit is approximately

FIG 8 GENERAL OUTLINE
Heater Piping is a Preliminary Plan only

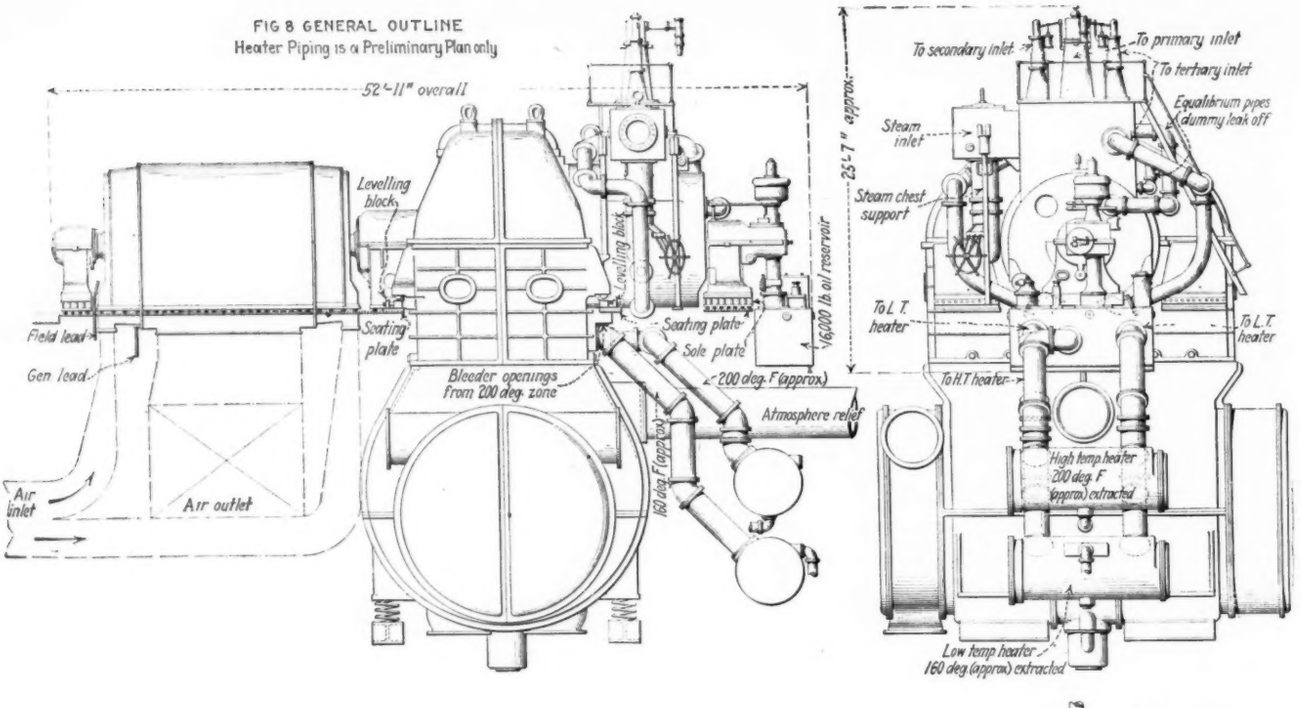


FIG. 9
Screw Chock Supports Bearing

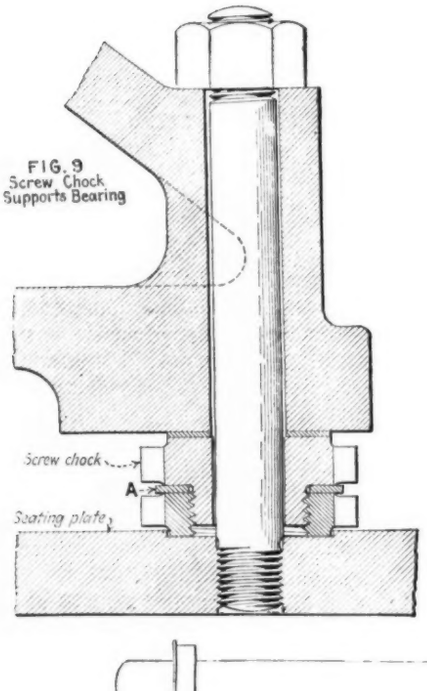
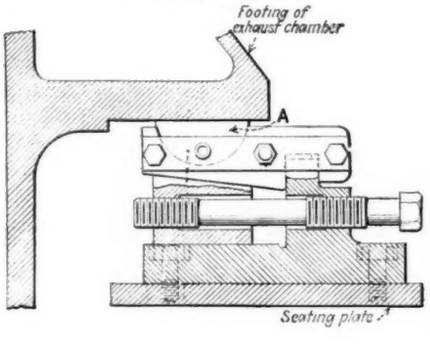


FIG 10
Bolt Adjusts Wedge



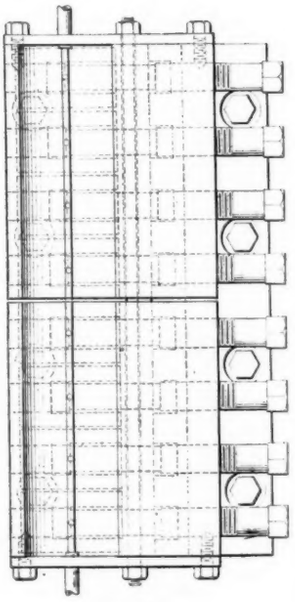


FIG. 11
Levelling Block

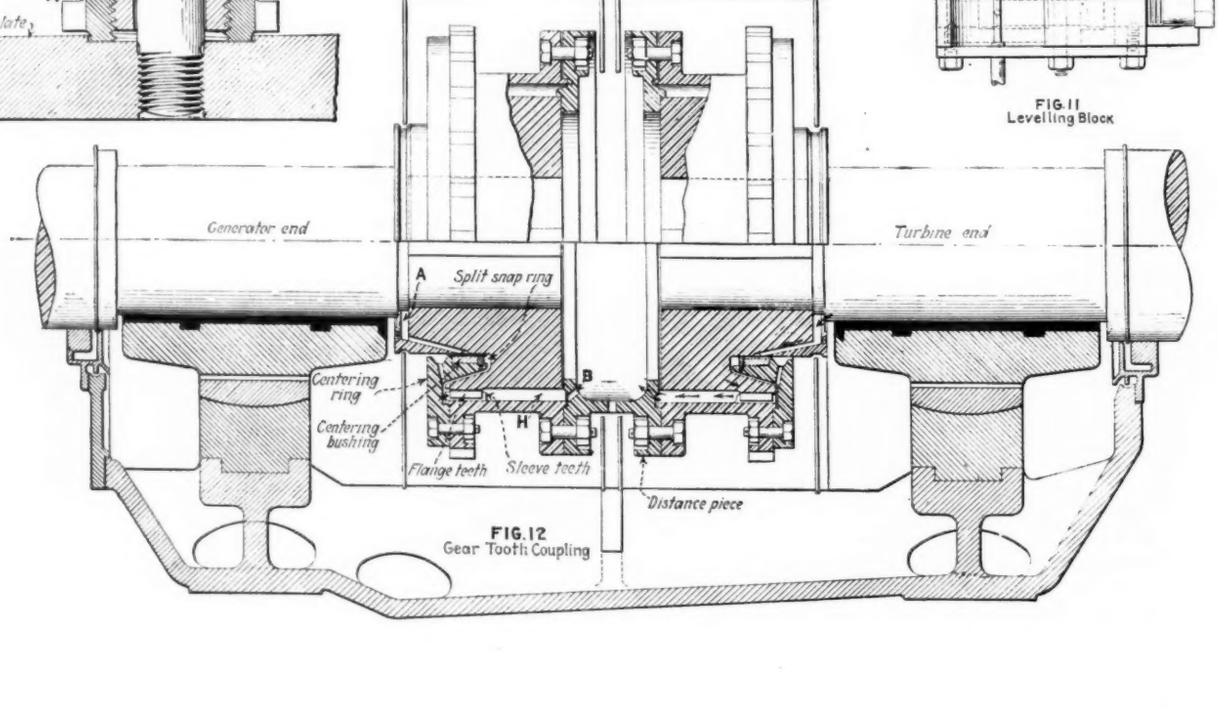


FIG. 12
Gear Tooth Coupling

53 ft. long by 25 ft. high by 24 broad. The total weight is 500 tons, the turbine rotor weighing 57½ tons, while the generator rotor weighs 50 tons. The condenser, which is suspended from the exhaust head, is also partly supported on auxiliary springs as shown. The foundation indicated in the drawing is only an approximation of a support and does not represent the actual foundation used. One seating plate extends the entire length of the generator. Each of the generator foundation bolts passes through an adjusting chock, shown in detail at Fig. 9. This may be screwed together or apart so as to lift the generator or lower it. It is thus possible to regulate the leveling without using shims.

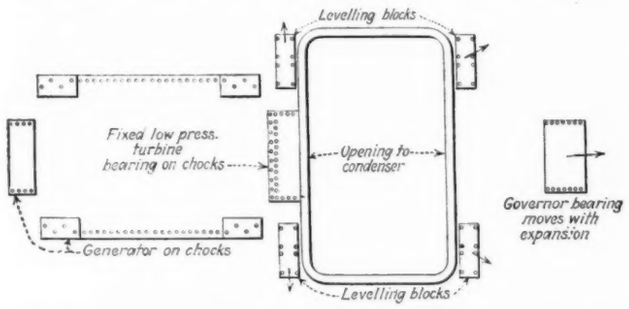


FIG. 13—TURBINE CYLINDER IS ANCHORED AT THE LOW-PRESSURE BEARING, AND EXPANDS FREELY IN THE GUIDES OF THE GOVERNOR BEARING SOLE PLATE

Chocks of the same kind are also placed under the bearing pedestal between the turbine and the generator.

For supporting the exhaust chamber four leveling blocks, one at each corner of the main casting, are used, two of which are indicated in Fig. 8. These can be adjusted to raise or lower by means of bolted wedges. The middle bearing is anchored securely, so that the expansion of the exhaust chamber is in the direction of the arrows indicated on the footings, Fig. 13. A semicircular shaft at *A*, Fig. 10, keeps the wedges approximately aligned and permits a flat bearing at all times against the exhaust chamber. The high-pressure bearing expands away from the low-pressure element. A sole plate supported on chocks permits this movement, containing a guiding surface on which the bearing pedestal rests. The directions of expansion are indicated in the plan, Fig. 13. After the proper adjustment has been made on each screw chock, a horseshoe-shaped washer *A*, Fig. 9, is installed between the upper and lower members, so that this adjustment will remain permanent.

The exhaust chamber contains partitions designed on stream-line principles. There are eight main divisions, four being shown in section, Fig. 7, each being split into three subdivisions, as in Fig. 5, making 24 steam passages discharging vertically downward to the condenser tubes. The differential of pressure between the blades and condenser tubes is somewhat less than that of the usual designs. The principal advantage of the large exhaust opening in the turbine with the stream-line partitions is the uniform distribution of the exhaust steam over the whole condenser inlet opening in a manner suited to give the best efficiency in heat transfer.

Leveling Is Adjusted from a Central Point

In order to secure as little expansion as possible at the point where the condenser is attached to the exhaust casing, the unit is anchored securely at the low-pressure bearing, as in Fig. 13. Expansion then takes place in the general direction of the high-pressure bearing, comparatively little movement being necessary on the condenser base itself. On the top of the condenser base is arranged a machined surface which is practically in the center. A straight-edge supporting the level may be swung on a pivot from this surface, as indicated at the top of Fig. 5. Vertical rods, which may be placed on several machined points on each of the four feet of the low-pressure casing as well as the high- and low-pressure bearings, are used for leveling. It is thus possible to obtain a number of accurately leveled spots on the turbine. The screw chocks and wedge footings make for convenience in leveling.

Attached to the rotor is a type of coupling tried for the first time on large machines. This is known as the Fast type, in which the engaging surfaces are gear teeth instead of pin and bushings, as otherwise are standard. Fig. 12 shows a more detailed view of this coupling. The coupling is shown in the lower half, while in the upper half the section represents the coupling as being removed and annular rings being

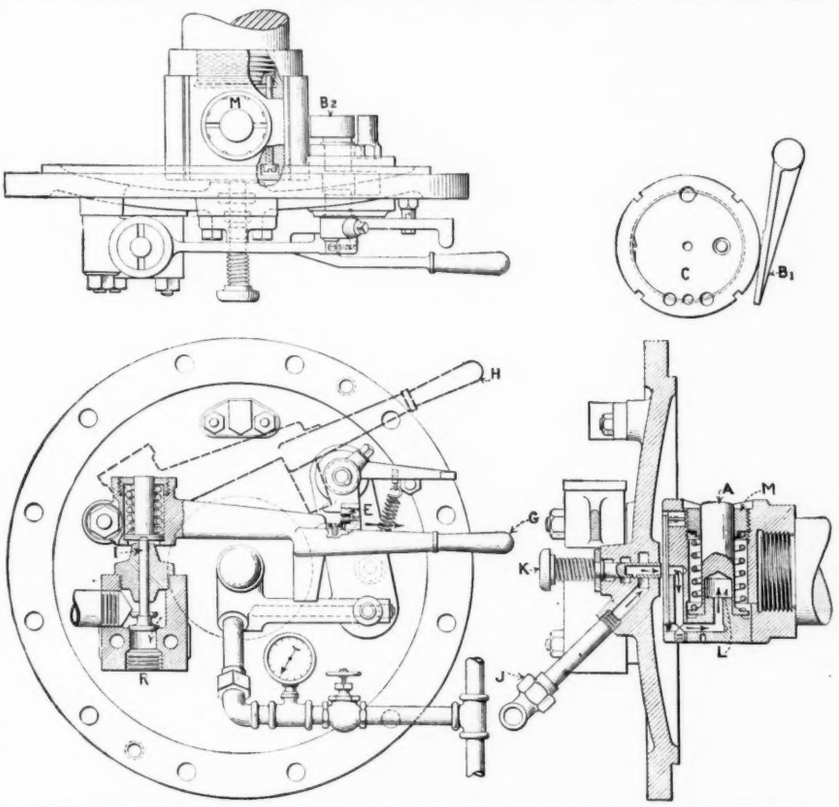


FIG. 14—EMERGENCY GOVERNOR MAY BE CHECKED AT NORMAL SPEED

The tripping member *A* may be operated at normal speed by means of oil pressure communicated to the piston. The oil is supplied by pushing in the knob *K* and regulating by the hand valve on oil pipe. Gage pressure required for tripping indicates the relative accuracy of the emergency spring adjustment. This is combined with the standard emergency governor gear.

clamped on the sleeve at either side. The purpose of these annular rings is to hold the sleeves in place in case it is desired to uncouple the generator from the turbine and operate the generator independently as a synchronous condenser. It is very easy to couple up by removing these rings and inserting a filler piece, which is shown in the bottom section of this coupling.

An interesting method of oiling the coupling is shown. Oil which drips into the groove *A* from the bearing at either end enters a groove *A*, Fig. 12, and passes along to the gear teeth, from where it finds its way into a channel *H* extending between the outer sleeve and the coupling flange. It will be noticed that the discharge at *B* slants toward the shaft center, so that the oil maintains a certain position against the outer teeth as a result of centrifugal force, before it can be discharged, which tends to hold an appreciable amount of oil always in place for lubrication.

Emergency governors as a rule are designed to shut off the steam when the turbine speed reaches 10 per cent above normal. However, in order to allow the tripping member moved by centrifugal force to resume its normal position, it was necessary in the original turbines, and is true of many of those of today, to slow down considerably below normal speed before the emergency mechanism would return to its safety position. This represented an objectionable loss of time in large units, so in recent years turbine builders have constructed emergency governors which will reset themselves or, in other words, return to normal position at the normal operating speed, rendering the excessive slowing down unnecessary.

Emergency Governor Can Be Checked at Normal Speed

Emergency governors of steam turbines were often tripped by hand in order to make sure that the stationary mechanism was working. Bringing the machine to the tripping point at 10 per cent above normal speed with a tachometer held against the turbine shaft, will show at what speed the emergency operates. The objection to tripping by hand is that the stationary parts of the mechanism only are thus tested, and the revolving element thrown out of place by centrifugal force is not moved. The objection to running turbines above speed for test is loss of time, and also, on account of its causing an abnormal strain, operators sometimes feel averse to tripping at overspeed as a regular procedure if it can be avoided.

Methods of overcoming these objections include attaching a weight of some kind to the moving element so that it will be thrown out of place at normal speed. If this weight is an auxiliary piece of metal of the proper shape and mass, it may be possible to tell whether the emergency is operating correctly by noting whether it trips exactly at normal speed or above or below. Such a method provides a test with fair accuracy for the functioning of the mechanism, but it involves shutting down for attaching and removing auxiliary weights. Another method includes weighting the moving element with sufficient oil to produce tripping, which provides a test for the working of this element, but not a means of gaging accurately whether the emergency would ordinarily trip at the proper speed.

The new type emergency governor shown at Fig. 14 includes a means of causing the moving element to operate at normal speed by admitting oil under pressure to act against this element and thus push it out of normal position. By measuring on a gage the actual pressure required to trip at the normal speed of the turbine, it is possible to check approximately whether the emergency governor operates at the correct speed. The moving element is arranged so that it will reset itself at some speed between normal and 10 per cent overspeed.

At the right of Fig. 14 the moving element is thrown out from the center of the shaft by centrifugal force when the turbine overspeeds the fixed amount. The speed adjustment is made on the holding spring by means of the nut *M* at the end, which can be locked in place when properly adjusted. Oil pressure is supplied to pipes at *J*, and is communicated to the revolving shaft by pressing in the handle *K*, which allows oil, as indicated by the arrows, to enter in piston at the bottom of the moving element *A*.

The gage shown at the left of the piping records the oil pressure which is turned on by the valve. After the emergency governor has been adjusted to operate at 10 per cent above speed or whatever setting is desired, the turbine is operated at normal speed and the emergency governor tripped several times by means of oil pressure, noting the gage reading each time. A test can be made at any subsequent date by operating the turbine at normal speed and noting the gage reading, which produces the tripping of the emergency. If this should be lower than the gage readings obtained with proper operation, then it is probable that the emergency spring has become somewhat weaker and would operate below the desired speed, and it would then be necessary to check accurately at the proper tripping point and adjust the holding spring accordingly.

This device is incorporated with the regular standard emergency valve gear, which operates in shutting down the turbine by opening a steam valve indicated at the left of Fig. 14. The opening of this valve allows steam to exhaust to atmosphere, relieving the pressure on one end of tripping cylinders, thus closing both the emergency throttle valve and the main steam valves.

In the detailed operation the element *A* flies out and trips the arm B_1, shown above, which is attached to the shaft as indicated at B_2, top view, and which causes the shaft to turn so that the latch *E* is moved in the direction of the arrow, relieving the arm *G*. This arm immediately takes the position shown at *H* and relieves the pressure on the valve stem *I*. This allows the steam valve to rise and exhaust through the opening *R*, as indicated by the arrow. The spring shown close to *E* holds the latch in position and is attached to the main faceplate which covers the end of the governor bearing.

The Springdale plant of the West Penn Power Co., where two impulse-reaction 20,000-kw. units are installed, was described in the Sept. 28, 1920, issue and is connected by two tunnels under the Allegheny River direct to the coal mine.

The guaranteed steam consumption of this unit at 300 lb. 650 deg. F. steam at the throttle, with a vacuum of 29 in. of mercury, is as follows:

Load	Lb. per Kw.-Hr.
1,750 kw.	10.30
26,250 kw.	9.75
35,000 kw.	10.15

At most economical load of 26,000 kw. the following amounts of steam are to be extracted:

High-temperature heater 12.9 lb. sq.in. abs.; 16,380 lb. per hour.

Low-temperature heater 3.20 lb. sq.in. abs.; 12,910 lb. per hour.

Gas for Use in Gas Engines

Notes on the Comparative Properties of Gases Tabulated for Easy Reference

BY JOHNSTONE TAYLOR

THE various artificial gases used in gas engines are ordinary coal gas (referred to as town gas), coke-oven gas, blue-water gas, blast-furnace gas and producer gas. By far the largest number of engines use the last-named gas which may be produced from anthracite, bituminous coal, coke and a wide variety of combustible refuse. Producers utilizing refuse are a comparatively recent introduction, and the nature of the fuel is so variable that no definite particulars of the gas produced can be laid down. As a general rule it is comparable as to calorific value with the gas from an anthracite producer. The appended table gives some particulars of these various gases so that they may be readily compared. It is drawn from the latest available data.

Town gas is used only to a limited extent in gas engines installed for continuous operation, owing to it being much more costly than producer gas. For stand-by plants, however, it is very useful and is an entirely satisfactory fuel.

Coke-oven gas is a cheap fuel in situations where it is available. It is necessary to extract the tar contained in the gas from the ovens, and the sulphur is injurious to steel piston rods of double-acting engines. Since the sulphur should not exceed 30 grains per 100 cu.ft., it is advisable to install oxide scrubbers to remove the sulphur and at the same time free the gas of tar and reduce its temperature. This gas should be supplied to engines under a slight pressure of from 1 to 2 in. of water. Hence it is necessary to force it through the scrubbers.

Producer Gas—The proper working of a gas engine on producer gas depends to a large extent upon the efficiency of the producer and the quality of the gas,

PROPERTIES OF GAS USED IN GAS ENGINES

Kind of Gas		A	B	C	D	E	F	G	H
B.t.u. per cu.ft.		560	415	300	124	124	157	140	95
Percentage by volume	H	43	52	52	14	15.6	17	26	1
	CO	10	7.5	42	25	20	23	11	28
	CO_2	....	5.5	4	6.4	6	5	16 9	12
	CH_4	33	21.5	1	....	1.1	3	2.7	....
	C_nH_{2n}	4	1.5	....	....	....	....	....	....
	N	10	2	3	54.6	57.3	52	43.4	59
Weight per cu.ft. lb.		0.036	0.027	0.042	0.07	0.068	0.066	0.066	0.083
Density (Air = 1)		0.45	0.34	0.52	0.87	0.85	0.82	0.82	1.04
Constituents of combustion products per cu.ft. of gas, at 760 mm. Hg.:									
CO_2		0.55	0.39	0.47	0.314	0.271	0.31	0.31	0.40
N		4.26	3.0	1.835	1.279	1.326	1.497	1.33	1.14
Water vapor		1.21	0.995	0.52	0.14	0.178	0.23	0.31	0.01
Total		6.02	4.385	2.825	1.733	1.775	2.037	1.95	1.55
Volume of air required		5.27	3.79	2.29	0.928	0.852	1.24	1.14	0.69

A. Town gas.
B. Coke-oven gas.
C. Blue-water gas.
D. Suction gas (coke).
E. Suction gas (anthracite).
F. Producer gas (bituminous non-recovery)
G. Producer gas (bituminous recovery)
H. Blast-furnace gas.

which must be cool, clean and dry. Most small and moderate-sized engines are operated by suction producers working under a vacuum of from 6 to 12 in. of water. For large engines and for operating several engines the pressure type is generally preferred. Suction producers may be worked by an exhauster and the gas stored in a holder. The supply pipes from any producer should be well drained. For large pressure plants of over 1,500 hp. it pays to work on bituminous coal and recover the ammonia. From 60 to 100 lb. of ammonia sulphate can be recovered per ton of coal, and its market value is considerable. Recovery plants are specially useful for working on cheap colliery waste, owing to its large nitrogen content, upon which the yield of sulphate mainly depends.

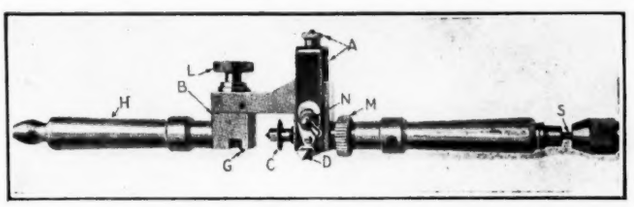
Blast-furnace gas is an ideal fuel for gas engines, especially slow-running double-acting engines, which are able to take full advantage of the slow-burning properties of this fuel.

While large quantities of this gas are often wasted both in England and America, in Germany the utmost use is made of it. The cleaning of the gas for use in engines, however, is of the utmost importance. Failure to effect this will most certainly lead to endless engine trouble. The cleaning demands a somewhat elaborate plant. Some of the cleaning systems are purely mechanical, while others operate on the electrostatic precipitation process.

Blast-furnace gas, when burned under boilers, will give only about one-third the power that it will do when used in suitable engines, consequently such engines are a sound commercial proposition in any plant having blast furnaces.

Motor-Driven Hand Tool for Undercutting Commutator Mica

With the exception of coal mines, foundries and like industries, the practice of undercutting the mica in commutators has been generally adopted. There are a number of different-shaped slots used, but the V-shaped



ASSEMBLY OF COMMUTATOR SLOTTER

is coming into favor rapidly. This type of slot is self-cleaning, thus preventing short-circuit between segments, automatically prevents undercutting too deeply, practically avoids the possibility of leaving strips of mica along the edge of the bars flush with the commutator's surface, and obviates the necessity of going over the commutator the second time to clean out the slots and remove the strips of mica found in U slots.

A new commutator slotting tool that cuts a V-slot has recently been placed on the market by the Martindale Electric Co., Cleveland, Ohio, which is driven through a four-foot flexible shaft from an electric drill and may be purchased either with or without the motor. The tool is shown in the figure, and cutter *C* is driven through shaft *S*. A guide *G* is provided to ride in the adjacent slot. This guide is adjusted to an approximate position by the sliding block *B* and locknut *L*, and the final adjustment to bring the cutter in the center of the mica is made by the micrometer screw *M*. The depth of the slot is regulated by raising or lowering the V-shaped guide by the depth gage screws *A* and is locked in place by locknut *N*.

A compressed-air line may be connected to the end of hollow handle *H* and air blown through it onto the cutter. This blows the mica away from in front of the saw and enables the operator to see his work clearly at all times. The nut holding the cutter on the shaft is cone-shaped and at the correct angle to deflect the air to the edge of the cutter.

Improved Method of Utilizing Old Firebrick

By JAMES A. FAULKNER
Refractory Engineer, Cleveland, Ohio

THE new plan is to grind up the old brick and add a binder to make mortar for laying up of the firebrick, and then to surface the wall with a layer of the same material. The coating is renewed once a month or as often as necessary and the wall is thus maintained indefinitely.

SOMEWHAT over a year ago an article appeared in these columns commenting on the writer's experience with monolithic furnace side walls made of old firebrick ground and mixed with cement. The plan was to remove the old firebrick wall, generally 9 or 18 in. thick, leaving in place, however, the occasional header row to tie the new monolithic wall to the standing wall. Months of experience has shown that this method is open to the objections that a monolithic wall of large surface may be subject to spalling and after the wall is burned away there is nothing left in the way of old brick to repair or replace it, so that it is a question of starting all over again and building up a new brick wall. Another objection was the fact that from 20 to 25 per cent of cement, costing $70 to $80 per ton, was added to the ground brick, making the expense almost as great as that of a new wall.

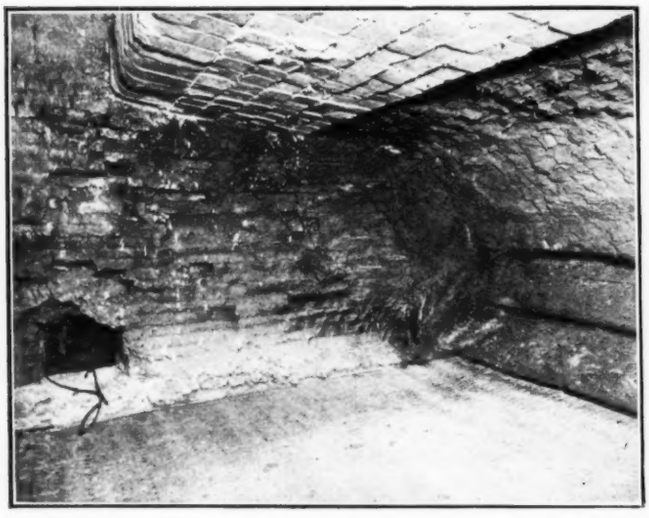


FIG. 1—BADLY BURNED FURNACE WALL READY FOR REPLACEMENT

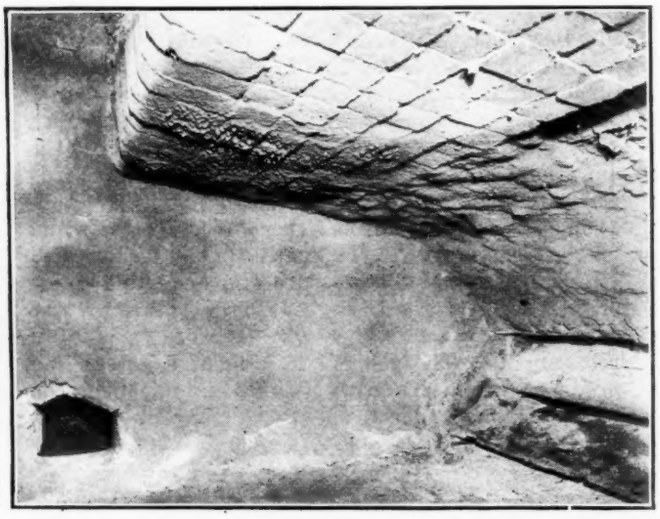


FIG. 2—SAME WALL 2½ HOURS LATER, COATED WITH FIREBRICK MORTAR

It has been found that a better plan is to grind up the old brickbats and by adding small amounts of high-grade clay and ground silica in the way of binder, make a mortar out of this material for laying up the firebrick. The surface of the wall is then coated with a layer of the same material from ¼ to ½ in. thick. With boilers operated at high rating, this layer is renewed every thirty days or as often as may be necessary, and the wall maintained indefinitely.

In making the firebrick mortar for laying up the wall and plastering the surface, Portland cement has been tried out and used with success where temperatures do not exceed 2,500 deg. F. The mortar that has given the best results, particularly for high-temperature work, is made by grinding the brick fine and then adding a small percentage of high-class bonding clay with a fusing point around 3,100 deg. F. This fireclay will shrink, so a certain percentage of finely ground silica ganister, which has a tendency to expand under heat, is added to balance the shrinkage of the bonding clay. Wetting this mass with a solution of sodium silicate, which vitrifies at a low temperature and gives a fine hard clay surface, completes the process. The result is a fine high-temperature cement or mortar, of which the base is your own firebrick calcined by months of exposure to the fire into the finest fireclay obtainable. In addition, it contains two high-refractory clays and the sodium silicate. Figured on the basis of one ton, the cost is approximately as follows:

Old brickbats	...
Clay for bonding	$3.00
Sodium silicate	0.40
Labor for grinding machine	0.60
Power	0.50
Total	$5.50

It is important that the base of mortar be as good a refractory as the brick in the wall and that no shrinkage takes place in the bonding material. Then the mortar will have no tendency to burn out before the brickwork. Any thickness of mortar between the brick may be employed from dip joints to joints ¼ to ½ in. thick. With a number of leading engineers the thicker joints are coming into favor, as they tend to relieve the expansion strains which, with a dip joint, come altogether on the brickwork. The evidence favoring the thicker joints is fewer expansion cracks in the brickwork and a reduction in the number of bricks required to make up the wall.

As a matter of fact, if the plan of coating the surface of the brick is followed out and this coating is

renewed at intervals as previously intimated, it makes little difference what thickness of joint is employed, as the fire is not given the opportunity to attack either brick or mortar.

Some difficulty has been experienced in finding a satisfactory cement to bind the coating to the glazed surface of the brickwork, but eventually it was discovered that Esso Bond No. 35 or No. 32 fine cement would do the work satisfactorily. Before the plastering operating is carried out, the entire surface of the brickwork is painted with a thin solution of this cement. The result is a secure bond between the brick and the coating.

Applying the Coating with a Cement Gun

If desired, a cement gun may be used to apply the coating. The same material goes into the mix, but it is prepared a little differently, as will be explained later. From a tank under pressure the sodium silicate is supplied to the nozzle of the gun and sprayed on the work along with the finely ground brick. Putting the sodium silicate into the mixture dry was tried, as has been done with certain high-temperature cements, but several difficulties arose. It was necessary to wet the walls. It they were too wet the material would slide, and if they were too hot they would dry out the material before the sodium was dissolved, giving a spotty set. As a result we resorted to the same practice adopted when applying the mortar with a trowel; that is, the glazed portions of the walls were sprayed with a thin solution of the cement. Then the ground material and the sodium-silicate solution were shot onto the wall and a perfect mix obtained regardless of the temperature of the brickwork. Using the cement in this way gave a sure bond between the brickwork and the coating and so simplified the job that it could be done with less-experienced workmen. A dollar's worth of the cement, reduced for spraying or for use with a whitewash brush, will cover 100 sq.ft. of surface, so that the additional cost is negligible.

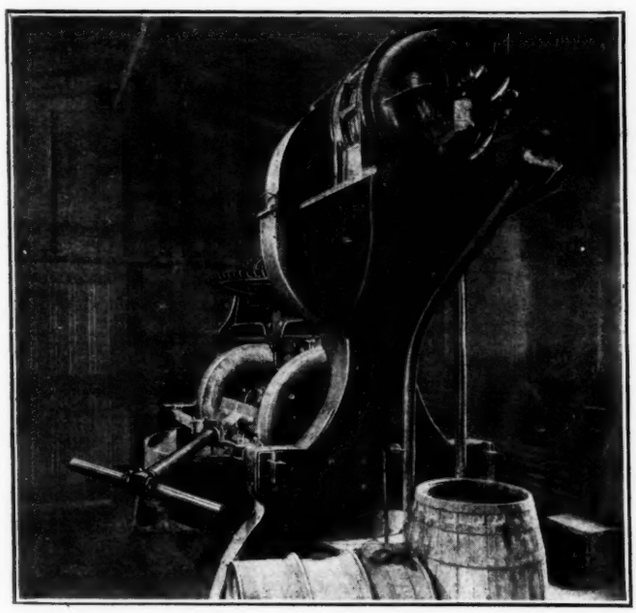


FIG. 3—WET PAN EMPLOYED TO DO THE CRUSHING, MIXING AND MILLING

After the work has been finished, the continued heat of the furnace vitrifies the coating and converts it into a thin monolithic wall. If this coating is renewed in the same manner every time it is burned out or through, the firebrick wall can be maintained at the same thickness almost indefinitely. The saving in the maintenance of the brickwork is not the only advantage, for if the wall is maintained at its original thickness, the radiation loss is a minimum. That is, less heat will go through an 18-in. insulated wall than through a wall of less thickness. In the course of a year the saving in heat is considerable.

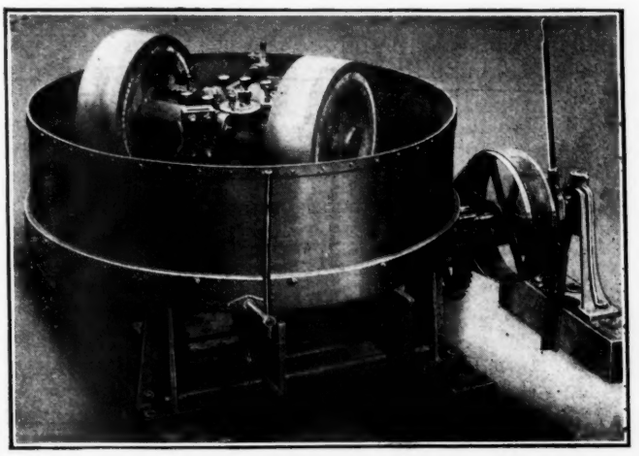


FIG. 4—VIEW OF SMALLER MIXER

It will be understood that the arches are treated in the same manner as the side walls and that the same ground brick material can be used to make one-piece baffles or for plastering over broken baffle tiles. For new baffles it is necessary to set the forms and make the mortar thin enough to pour.

Beginning the Repair Work

In repairing furnace walls and arches and monolithic work, the first operation is to fill up the spalled portions with a plastic firebrick similar to the mortar only ground coarser and mixed much drier to the consistency of core sand. To wet the mixture, water is used instead of sodium silicate. In monolithic work or in making thick patches, it has been found that where sodium silicate or any high-temperature cement containing it, is used, the heat of the furnace vitrifies the surface to a depth of an inch or so and when the material behind dries out, the hard crust peels off. When the plastic firebrick, which is practically a green brick, has been prepared, it is hammered into the depressions in the wall and burned in the furnace. After the wall has been brought back to its original thickness in this way, it is coated with the cement solution and a coating of mortar applied with a trowel or the cement gun, as before.

In obtaining equipment for this work, it is just as necessary to get a machine that will do the mixing as a machine for the grinding. Several times we have tried to take the material dry and mix the mortar with a hoe, but it never compared with the machine-mixed-and-ground material. We have been using two machines of different make for the purpose. Both operate on much the same principle and do practically the same quality of work.

After the crushing is done, the binder and liquid are added and the mortar thus formed is mixed and mulled to the proper consistency. A great deal of the success of making a plastic clay depends on the mulling in the machine after the material has been moistened.

To follow through the process, the man in attendance brings in a wheelbarrow full of old brick, usually weighing 200 lb. These brickbats are dumped into the pan and the process is repeated four times, making 800 lb. in all. With a pail previously weighed and marked for the proper quantity, the binder is dumped into the pan with the grog. Beside the machine is a barrel containing the proper solution of sodium silicate. By the time the binder has been added the brick are fine enough to wet down with the solution in the barrel. The heavy mullers working through this wet mass and rubbing the wet material on the bottom of the pan give it a plasticity that can be secured in no other way.

Mortar Prepared in Half an Hour

The entire operation takes about half an hour. At the end of this time the material has been worked into the proper consistency and the operator shovels the mortar from the pan to the waiting wheelbarrows, in which it is taken to the job ready for use.

Material to be applied with the cement gun is ground dry. It has been the custom to grind 200 lb. of the brick very fine and mix it with the binder, thus practically making the cement first. Then the remaining 600 lb. of brick is dumped into the pan and ground rather coarse.

With the smaller mixers the process is practically the same, except that it is necessary to break up the brickbats before putting them into the grinding pan.

It is sometimes necessary to repair red brickwork, and here again the grinding and mixing machine is a great convenience. It is not always convenient to carry sand and cement and keep a mortar box for this work. It is easier to have the helpers pick up a wheelbarrow full of clinkers drawn from the ashpit and dump them into the pan, where they are ground fine. To every 200 lb. of clinkers a 50-lb. bag of hydrated lime is added and the mixture is wetted to the proper consistency. For boiler or any other red brickwork, a much better mortar is made in this way than with the usual sand and cement. In a certain plant where the mixture was made of two-thirds ground clinkers and one-third slacked lime, the cost of the mortar approximated $2 a ton.

Savings Effected in One Plant

As to the saving that may be effected by utilizing the old firebrick, this varies with the plant and the conditions existing. Perhaps the better way would be to cite a specific case and allow the reader to form his own conclusions.

In one boiler room containing thirty-two large boilers operated at high rating, so much trouble had been experienced with the furnace brickwork that three, four or five boilers were out of commission at all times for repairs to the brickwork. High-priced bricklayers were doing the work, and high-priced cement was being used to lay up high-priced brick.

After adopting the method under description, the high-priced cement was eliminated, the walls were plastered and a regular schedule adopted whereby every Friday night four boilers were taken off the line, the load being light in this plant Saturday afternoon and Sunday, so that it was necessary only to operate the remaining boilers a little harder Saturday morning to carry the load. The brickwork in these boilers was repaired and the walls and arches plastered, mostly with trowels but sometimes with a cement gun, either way proving satisfactory. In some cases the coating was burned through in spots and in others its thickness was reduced, but in either case the entire surface was gone over. The boilers were washed and inspected for minor repairs and put back on the line as soon as the work of plastering was done. On the following night four more boilers were treated in the same way.

Taking eight boilers in this way each week, the thirty-two boilers were overhauled every thirty days and, barring any other trouble, were on the line for the heavy loads the rest of the week. It was not necessary to push them above their most efficient steaming capacity, as was often the case when there were boilers down at all times for repairs to the brickwork. This has been going on for months. The walls burn through in time, but at least their life has been doubled and the equipment has been kept in almost continuous service. It has even been found profitable to buy old brickbats at a low figure to help out in this work.

Burned Wall Before and After Repair

Fig. 1 shows a badly burned wall that ordinarily would have to be replaced by a new brick wall requiring 1,200 firebrick at, say, $50 to $60 a thousand, and 450 lb. of high-temperature cement costing 4c. a lb., or a total of $18. In addition to the labor for tearing down the old wall the services of two bricklayers and two helpers would be required for all of one day. The arch is in bad shape, but would have been good for another month.

In Fig. 2 is shown the same wall 2½ hours later. The wall was repaired with $1.60 worth of cement and 1½ tons of ground brick mixed according to the formulas previously given, at a cost of $6 a ton at the job. One man at 75c. an hour and two men at 60c. repaired the wall and the arch in 2 hours and 10 minutes, and the boiler was back in service 24 hours after it was taken off.

Fig. 3 shows the machine that prepared the material. It is of large size, having a pan 7 ft. in diameter, in which the crushing, mixing and mulling are done in one operation. One of the smaller machines is shown in Fig. 4. The construction is somewhat different but the principle of operation is the same, the choice between the two machines depending largely upon the quantity of work to be done.

Vertical turbines have been superseded by the horizontal type. On account of step-bearing trouble that was encountered in the early days, this feature has been considered largely responsible for their lapsing into disuse. If this were the only reason, however, vertical turbines could now be run very satisfactorily, as the Kingsbury thrust bearing is a practical solution. The main objection is lack of rigidity. The lowest bearing is held rigidly by the foundation, but the next two higher bearings—the middle and the top—are considerably more flexible and, therefore, more subject to vibration. In a horizontal turbine all bearings are tied rigidly to the foundation, and therefore it is less sympathetic to vibration than a vertical type. Some of the finest running turbines, nevertheless, have been of the vertical construction.

Protection of Electric Motors

By Gordon Fox*

The first function of a controller is to make possible the effective use of a motor. Its second function is to protect against damage and abuse. Protective features are in the nature of additions or ramifications upon the elementary needs for the purpose of extending the service that the control may perform.

Overload Protection

Motors are constructed in various sizes and types, each having limitations in its ability to convert electrical into mechanical energy. A great excess of electrical input into a motor will damage it by burning at contacts or by overheating. An excess of mechanical output may damage either the windings or the mechanical parts of a motor owing to the excessive stresses, and it may also damage the driven machinery. In order to prevent damage to both motors and driven machines, some means is desirable to limit the electrical input and mechanical output. This may be done either by disconnecting the motor entirely from its source of electric power or by modifying conditions to decrease the load. The more common procedure is to open the motor circuit when the load exceeds the safe prescribed value.

Momentary and Sustained Overloads

Momentary extreme loads may damage a motor either by flashing at the brushes or by excess mechanical stresses. A motor may also be damaged by sustained overloads which are insufficient to damage it except by heating. It is desirable to permit moderate overloads to be carried for short intervals, but to prevent their continuance to an extent sufficient to overheat the motor. This is ordinarily accomplished by the use of a protective device having a time lag sufficient to prevent operation on momentary peaks, yet operative under sustained overloads.

Methods of Overload Protection

The most common overload protective devices are fuses, circuit breakers and overload relays, the last-named being used in conjunction with contactors or switches.

Fuses are relatively cheap in first cost. Renewal costs may be high if fluctuating loads or other conditions render frequent renewal necessary. They introduce a slight time-element feature; that is, they will carry an overload for a short period before blowing. They are not highly accurate as to calibration, are liable to substitution and overfusing by operators, and such practices are not readily detected. The difficulty in locating a blown fuse and the delays incident to removal are often disadvantageous.

Circuit breakers have the advantage of low maintenance cost, quick indication of opening and quick reset. They are supposedly accurate of calibration but not always so. They afford a considerable range of setting and indicate the setting in use. Circuit breakers of the air-break type are commonly used for direct-current work and to some extent for alternating-current service, particularly in the smaller sizes. Oil circuit breakers are used for the more severe alternating-current duty.

Overload relays are devices that serve to make or break a pilot circuit which, in turn, causes the opening or closing of circuit breakers or magnetic contactors. These relays are generally magnetically operated by a series coil which is connected in the motor circuit directly or, on alternating-current circuits, through current transformers. These relays are subject to calibration over a fairly wide range. They are commonly of the solenoid and plunger type. Calibration is obtained by adjustment of the position of the plunger.

Overload Relay Coil Arrangement

Overload relays may be equipped with series coils only or series and shunt coils may be provided. When series coils only are provided, the relay will hold open only while current flows in the series coil, unless a catch is supplied. Where both series and shunt coils are supplied, the series coil acts to open the relay and the shunt coil then suffices to hold it open so long as the current continues in the shunt coil.

These relays may be instantaneous in their action, or a time element may be introduced through the use of a dashpot. The instantaneous trip relay protects effectively against short-circuits, grounds and similar severe conditions, but will not always protect against sustained moderate overloads because it is usually necessary to set an instantaneous trip relay or circuit breaker rather high to prevent tripping on fluctuations or peaks of short duration. The time-element feature enables a relay or breaker to be set at a value sufficiently low to protect a motor or line from injury due to sustained overloads, at the same time permitting short peaks without tripping. This feature is particularly desirable where fluctuating loads are involved. It is useful for overload protection of squirrel-cage induction motors, as the setting may be made such as to protect the motor while running, yet hold in during the brief peaks incident to starting.

Time-Element Feature in Relays

The time-element feature is ordinarily obtained through use of an air or oil dashpot. With air dashpots close fits are required and the air discharge opening must be small, making accurate adjustment and maintenance of calibration difficult. Oil dashpots are more generally used. One drawback is the change of viscosity of oil with changes of temperature. Special oils are available which minimize this disadvantage, but they do not entirely eliminate it. It has been the writer's experience that those dashpots are most reliable which use fairly heavy oil and a rather large opening through the piston. These are not seriously affected by dirt nor by variations of piston clearance. Time-element overload relays ordinarily have an inverse-time action requiring little time to open under a short-circuit, but acting rather slowly under a moderate overload. Overload relays may be further described as instantaneous-reset, automatic-reset, and hand-reset.

The instantaneous-reset relay closes at once when the current in its operating coil falls. The automatic reset relay, once opened, remains open until reset, either by opening its shunt-coil circuit, or by energizing a reset magnet which trips the catch that holds the relay open. Hand-reset relays, once open, remain open until reset by hand. Each type finds applications according to the conditions to be met.

In grinding commutators with an abrasive wheel, good results can be obtained only when the grinding is done on the high spots first, and then smoothing.

*Electric Engineer, Freyn Brassert and Company, Chicago, Ill.

New Saginaw River Steam Generating Station of Consumers Power Company

AT ZILWAUKEE, a small town on the Saginaw River, three miles north of the City of Saginaw, Mich., the Consumers Power Company has started the construction of a 100,000-kw. steam-generating station that will have a number of novel features. Exceptional fuel economy is expected through a number of special arrangements, prominent among them being the extraction of heat from several stages of the main units by the entering air as well as the feed water.

The initial installation, consisting of two 20,000-kw. impulse turbo-generators, will be made within the coming year. It is expected to start up the first unit about Dec. 1 and the second unit in March, 1924.

At the site of the plant the company owns an extensive acreage along the bank of the Saginaw River, so that coal may be received by boat, although for the present it will be shipped by rail over the Grand Trunk and Michigan Central railroads, which have sidings running to the property. Practically all the equipment and material has been purchased and construction is progressing on schedule time.

ULTIMATE capacity of station 100,000 kw. Initial installation, two 20,000-kw. turbo-generators. Two boilers per turbine. Steam pressure, 375 lb. gage; superheat, 250 deg. F.; steam temperature, 692 deg. F. Hydraulically operated stokers, radiant superheaters, castiron economizers, special coal handling and hydraulic system of sluicing ashes. Steel heating surface passing through cast-iron bricks line furnace side walls. One-pass pear-shaped condensers using $\frac{3}{4}$-in. tubes. Big feature of plant, preheating air as well as heating feed water by bleeding the main units.

Two boilers will serve each turbine unit. Each will contain 8,870 sq.ft. of steam-making surface and will be fired by underfeed stokers of the new hydraulically driven type, having double-roll clinker crushers. Above each boiler will be a double bank of vertically baffled cast-iron economizers which will have a total of 8,500 sq.ft. heating surface per boiler. The superheaters will be of the radiant type installed in the back walls of the furnaces. The boilers are designed for a working pressure of 375 lb. gage, and the steam will be superheated approximately 250 deg. F.

To a level above any possible flood stage of the river, the building for the new plant will be of waterproof reinforced-concrete construction, and above this elevation will be a steel-supported brick structure. There will be stub steel stacks, one to each boiler. Coal will be dumped through track hoppers into an automatic vertical skip hoist which will discharge through crushing and weighing apparatus onto a shuttle belt conveyor traveling on a truck over steel-plate bunkers. Excess coal will be spouted by gravity from the skip-hoist tower back to the yard and spread out into storage by a drag scraper.

The ashes are to be ground through the clinker crushers of the stokers and dropped on secondary grates, which can be dumped by hand into a concrete sluiceway supplied with water from the circulating system of the main condensers. Through this sluiceway the ashes will be carried hydraulically to a well, from which they will be raised by motor-operated manganese-lined dredging pumps to a wooden launder which in turn will carry the mixture of ashes and water over an extensive piece of property that it will take many years to fill in. The pumps will be capable of handling lumps of clinker up to 8 in. in diameter. The pump suction will be protected from larger chunks by a grizzley or grating placed horizontally, on which a considerable number of large clinkers can collect without clogging operations. Such clinkers can collect only as a result of poor operation of the clinker grinders, so that they should be of infrequent occurrence, but if they do collect, they will be broken by hand so that they will drop through the grizzley.

Makeup water will be purified by means of evaporators connected between the bleeders on the eighth and eleventh stages of the turbines. For each turbine there will be one evaporator having a maximum capacity of 10,000 lb. an hour. A large storage reservoir for condensate will be provided between the foundation walls, under the boiler-room basement. With the evaporators taking steam from the eighth stage of the turbine and delivering their vapor into the eleventh-stage bleeder pipe, a number of pumps and other auxiliaries common to low-pressure evaporator plants will be eliminated. In this particular installation no evaporator feed pumps will be needed, as the water will feed to the evaporators by gravity from the house cold-water service supply tank.

Deaëration of the feed water will be accomplished by admitting all condensate that has been exposed to the air in storage back into the system through the main condensers, the hotwells of which will be so designed that they will deliver it practically free from dissolved air and at a temperature higher than that corresponding to the pressure of the vapor in the condenser.

Air for combustion will be admitted to the building through louvers and heaters in the top of the boiler house and drawn down through ducts carrying with it waste heat from boiler-room radiation into the forced-draft fan room. After passing through the fans on the way to the stoker wind-boxes, the air will be preheated by means of hot water and steam bled from the main units to a temperature of 250 to 300 deg. F.

Another interesting feature will be the substitution of steel heating surface protected by cast-iron blocks for those portions of the furnace lining submitted to the most severe service. It is anticipated that this construction will do much toward the reduction of furnace brickwork troubles. This particular form of heating surface will consist of steel tubes running through what will be in effect cast-iron bricks taking the place of the usual firebrick and being water-cooled. The water will circulate to a steam drum and will be under the same pressure as the boiler. It has been calculated that these

water-cooled furnace linings will generate steam to correspond to a rate of heat absorption of 60,000 to 80,000 B.t.u. per sq.ft. of exposed surface per hour, which is about twice as much as has been found to be evaporated in the water screen tubes of powdered-fuel installations.

Three-phase 60-cycle current will be generated at 12,000 volts and stepped up to 24,000 volts by means of auto-transformers, one of which will be connected directly to each turbo-generator.

As the plant will be nearly 800 ft. from the river, long intake and discharge ducts for circulating water will be required. A concrete intake house will be built large enough to accommodate chain-belt traveling screens and the condenser circulating-water pumps. There will be two of these pumps having a capacity of 22,000 gal. per min. each and one of 35,000 gal. per min. to take care of the first two condensers. The condensers will be pear-shaped and fitted with ¾-in. tubes and will be built for one pass only. They will have air-cooler sections made up of cast-iron surfaces, and the water-box will be divided so that half the surface can be cleaned while the other half is in use. On account of the extensive use of steam for preheating feed water and air, the condensers do not need to be large, the actual surface to be installed in each unit being 14,250 sq.ft., or about 0.7 sq.ft. per kilowatt of generator rating. This does not take into account the cast-iron air-cooler sections, which are equivalent to a large quantity of brass tube surface.

How the Motors and Controls Are Arranged

Each boiler will have its own forced-draft and induced-draft fans controlled from the boiler control board. To provide for maximum efficiency and ease of control, a novel arrangement of motors and controls has been worked out.

For the forced draft a 15-hp. 720-r.p.m. motor and a 100-hp. 1,200-r.p.m. motor are direct connected on the same shaft with the fan. These are 440-volt alternating-current slip-ring type motors with the 720-r.p.m. motor designed for safe overspeed. Each motor has its own controller, which is of the motor-operated drum variety, and the controllers are so connected and interlocked that by the operation of one push-and-pull switch on the boiler control board, any fan speed from 360 to 1,200 r.p.m. can be obtained. When the drum controller of the small motor has reached its top speed, a contactor automatically cuts this motor off the power circuit, another contactor energizes the larger motor, and its controller will then accelerate to the maximum speed with the small motor merely coasting.

The induced-draft fan is driven by a 40-hp. and a 150-hp. motor connected similarly, the former being connected by a chain drive, while the large motor is direct connected to the fanshaft.

This makes for extreme simplicity of control as far as the operator is concerned, and provides for considerable economy of operation, especially when it is considered that the small motors will furnish the necessary draft for a large proportion of the time, the large motors being called upon only when the boilers are operated at very high ratings. This construction gets away from the necessity of direct-current power in the station, avoids the expensive maintenance and difficulties with the brush-shifting type of motor, and provides an unusual speed range with exceptional efficiency for slip-ring motors on fan duty.

Differential relay protection will be provided for the generators and auto-transformers so that a failure in either the generator, the connecting cables or the auto-transformer will trip the switch connecting the auto-transformer to the bus, open the generator field and close the throttle. The generators have an entire self-contained air-cooling system, which circulates the air through water-cooling coils, the total volume of air in the system being so small that in case of incipient fire in the generator windings the oxygen would hardly support combustion for the small amount of dust that might be present in the windings. On this account no water, steam or other fire-fighting equipment is provided. The coolers are supplied with water from the general cold-water supply system of the station and are merely a part of the feed of cold water to the transformers and other auxiliaries, the temperature rise of the water through the air-cooling coils being so small as to make it available for cooling all other equipment after serving to cool the generator air.

The excitation for each unit is the result of the favorable experience of the Consumers Power Company with individual direct-connected exciters separately excited. Each exciter consists of a 110-kw. 250-volt shunt unit direct connected to the turbine shaft, while bracketed and direct connected to the end of this exciter is a small 2-kw. 125-volt machine which excites the field of the main exciter. There is no main series field rheostat provided, nor is a Tirrill regulator used. The elimination of the series rheostat does away with the large losses always present in such equipment and provides for maximum stability because of the separate excitation of the main exciter. There is no spare excitation provided.

All Switching and Transforming Equipment in Outdoor Substation

Following the practice of the company for the last ten years, all the switching and transforming equipment will be placed in an outdoor sub-station erected adjacent to the steam plant. This will include not only the auto-transformers, served underground from the generators, but also the 24,000-volt duplicate bus, together with the 24,000-volt switches, which have a 50,000-volt rating.

The station power transformers consist of three 500-kva. self-cooling units stepping down from 24,000 to 480 volts, one bank supplying all the station auxiliaries for the first two units. Future units will obtain station auxiliary power from a second station power bank. To insure as much as possible against transformer failure, the station power transformer will be built to 50,000-volt transformer specifications.

The regular engineering department of the Consumers Power Company is handling all the engineering in connection with the project, and construction is being carried out by the construction department of the company. The information in this article is supplied by H. F. Eddy, their mechanical engineer.

C. E. Stromeyer, in his "Fatigue of Metals," says: "From 1870 to 1914 no better law of fatigue had been formulated than that comparatively small stresses, if repeated often enough, will ultimately cause a failure. A fatigue limit was only believed to exist. Now, however, that it has been definitely established that there is a fatigue limit, further experiments need only concern themselves with its value."

Details of Indianapolis Turbine Wreck

FAILURE of a 10,000-kw. turbine at the Mill Street station of the Indianapolis Light & Heat Co. on April 2 was briefly reported in the April 10 issue. Since then photographs and more detailed information have become available.

The wreck occurred at 5:40 a.m., just as the unit was being brought up to speed preparatory to putting on the line. Steam had been on the turbine for over an hour in warming up, with the rotor turning over, and the generator fields had been excited. The machine had been in service since 1916. Only two men were in the turbine room at the time, one being at the throttle. While this operator and one of the others were injured, there were no fatalities.

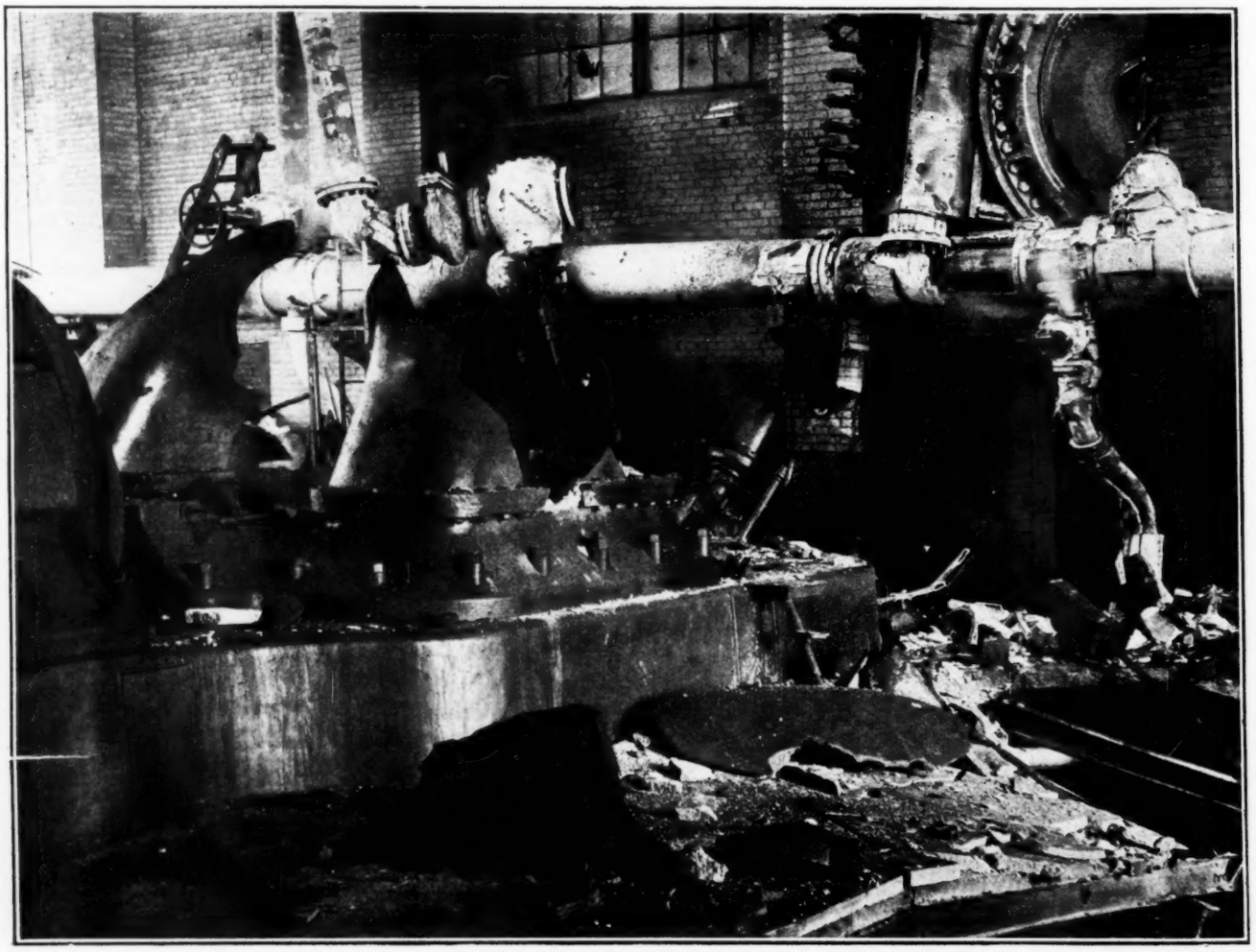


FIG. 1—END OF CASING AND VALVE CHEST HURLED ONTO STEAM MAIN

Reference to the sketch (Fig. 3) will give an idea of the layout of the turbine room and indicate where some parts of the wrecked turbine were hurled. The turbine room contained three other units—a 15,000-kw. machine, known as No. 7, which was in service at the time; a second 15,000-kw. unit, No. 6, which was out of service with the cover removed for overhauling, and a 5,000-kw. vertical unit held as a reserve.

The blading on No. 6 unit was damaged by flying pieces of the wrecked unit and a large coupling from between the turbine and generator of the latter, which weighed in the neighborhood of 1,500 lb., was hurled over the 5,000-kw. vertical unit, struck the overhead crane and dropped near No. 7 unit. Other flying pieces broke the oil lines on this unit and put it out of service. The rotor and valve castings of the destroyed unit broke the 12-in. steam line and the step-bearing pumps, and tipped over the 50-ton accumulator of the vertical unit. Thus every machine in the station, a total of 45,000 kw. capacity, was temporarily rendered unfit for service.

At the time of the failure a number of boilers were on the line and being made ready for the 7-o'clock peak load. The boiler-feed pumps in use were motor-driven, as were also the pumps supplying the heaters. Therefore, when the generating units were put out of service and the tie-in connections with the Kentucky Avenue plant opened, the Mill Street station was completely isolated. As soon as the rush of steam through the broken main had been stopped, the boilers began blowing off, and the danger due to low water became apparent. Reserve steam boiler-feed pumps were quickly started, but as there was no electricity available for the

motor-driven cold-water pump and the steam supply to the steam-driven cold-water pump had been broken, no water could be supplied to the heater. The only reserve left was the city water, which was inadequate.

The large chain-grate and underfeed stokers could not be dumped immediately and, water being temporarily unavailable, the fires could not be quenched. Hence it became necessary to call the fire department. In the meantime jumpers were run to the buses and tied in with the Kentucky Avenue plant; the feed pumps were started, and gradually each boiler had its water level brought up. No fuse plugs were lost, and the only damage to the boiler plant detected was a broken support for a superheater. By 6:30 the steam pumps were in operation and by 7:30 the boiler plant was under complete control, the steam header sectionalized and steam again on No. 7 turbine, the oil lines of the latter having been repaired and the oil replenished.

It was decided, however, not to place No. 7 machine in regular service until the generator and exciter had been completely tested out, inasmuch as the vast amount of steam liberated had drenched all the equipment. These tests were expedited and by 2:30 p.m. this machine had been put on the line, and the station began to carry part of its regular load. Two days later the vertical unit was placed in service, and by April 6 the second 15,000-kw. unit had been placed in service and full operation was resumed. A new 15,000-kw. unit of the same make has been ordered to replace the wrecked one and will be placed on the same foundation. The wrecked turbine was a single-cylinder horizontal General Electric machine running at 1,800 r.p.m. under 235-lb. pressure.

The 14-in. main steam header was of wrought steel with cast-steel flanges, operating under 235-lb. pressure and 200 deg. superheat. All the valves were of cast steel with outside screw and yoke. It is to be noted that the valves stripped the bolts and nuts on the joints. These valves are now back in service after supplying new bolts and gaskets, and they are tight. The only part of the piping that had to be replaced was a piece of 10-in. pipe 2½ ft. long, six gaskets and six sets of bolts, two wall brackets and four expansion rollers. The end sections of the main header were ready to use shortly after the accident by closing two valves, and the center section was ready within 24 hours.

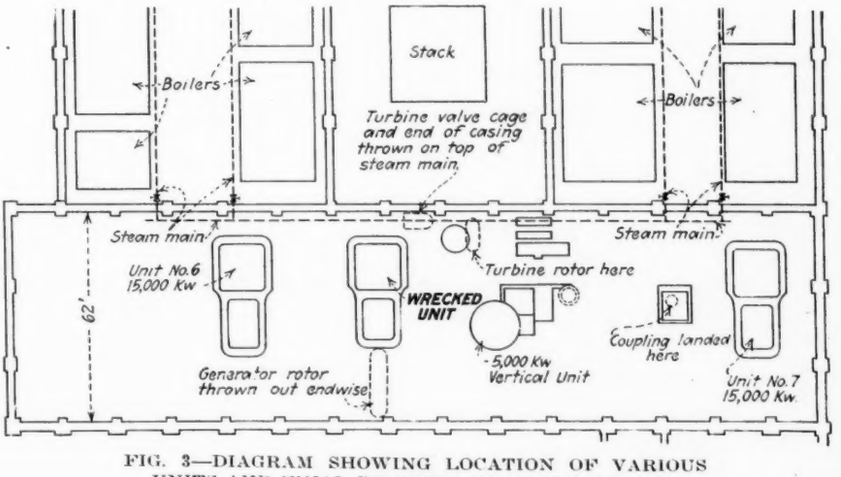


FIG. 3—DIAGRAM SHOWING LOCATION OF VARIOUS UNITS AND FINAL POSITION OF CERTAIN PARTS

FIG. 2—SHAFT BENT AND BROKEN

According to an official of the Indianapolis Light & Heat Co., the cause of the failure has not been definitely determined. The evidence, however, seems to point to a runaway as the cause. It was difficult to tell from the broken parts which was the initial break. It may have been that the first-stage rotor disk failed where the dove pins held it to a sleeve which in turn was keyed to the shaft, or that one of the low-pressure disks failed first and threw the rotor out of balance. Pieces were broken out of the disks in several places.

A manufacturing company in the East had twelve boilers with 3,000 sq.ft. of heating surface each. They were of an old-fashioned type and fitted with old-fashioned overfeed stokers. They had reached the age at which the state law reduced their pressure to 150 lb., which made it impossible to operate numerous machines which required a minimum of 150 lb. at the throttle. It was decided to scrap the battery and install new boilers designed for 200 lb. pressure and equipped with underfeed stokers of a modern type. The results have been that instead of burning 250 to 275 tons of coal per day, the average consumption under the same load conditions has fallen off 40 tons a day on an average. The coal costs $6 a ton, so that this saving amounts to $240 a day.

Foundations for small or medium-sized turbines usually consist of solid blocks of concrete. Those for large machines, as those in central stations, contain a platform or slab supported by steel, concrete or composite columns, which in turn rest on a rigid slab of solid concrete.

Proper Steam Pressures for Absorption Refrigerating Machines

By A. W. AKINS

MOST men who operate absorption refrigerating machines have a general idea concerning the steam pressures necessary to be carried on the generator for different temperatures of the condensing water, but few know why the steam pressures must be raised as the temperature of the condensing water increases. Neither do many know why a higher steam pressure is necessary when the machine is operating with cold brine than is required on machines operating on comparatively warm brine. When warm condensing water is used or when the machine is working on very cold brine, the machine is often overcharged, for there is a common impression that under these conditions the charge must be strong.

The strength of the charge is too frequently tested by the use of a hydrometer and an effort made to keep the charge up to a certain strength, but when the principles governing the steam pressures required on the generator are fully understood, it will be found that the hydrometer is really not a necessity. The steam pressure to be carried is not an arbitrary figure set by the manufacturer, but it is calculated accurately and is dependent, first, on the temperature of the condensing water and, second, on the temperature of the brine carried in the cooler.

If the condenser coils are clean and free from foul gas and the water supply is sufficient, the head pressure is governed by the temperature of the condensing water. The surface in the condensers should be such that the maximum head pressure carried will not be more than 30 lb. greater than the pressure at which ammonia condenses when cooled to a temperature corresponding to the initial temperature of the condensing water. Thus if the initial temperature of the water is 70 deg., the condensing pressure of ammonia for this temperature is 113.7 lb. gage and adding 30 lb. to this gives a maximum acceptable head pressure of 143.7 lb. gage. When the head pressure passes this point, the underlying cause should be found and the trouble rectified.

Concentration tables for ammonia liquor show that, with a given pressure in the generator, aqua has a definite boiling temperature. The table shows that with any stated pressure, the boiling temperature becomes lower as the percentage of ammonia in the solution increases. Therefore when the head pressure begins to rise owing to the condensing water getting warmer, the boiling point of the charge in the generator can be lowered by increasing the strength of the aqua, a fact that raises the question, Why, then, is it necessary to raise the generator steam pressure? The reason is that the strength of the liquor coming from the absorbers must also be considered. Here again the concentration table for aqua ammonia must be used, because the strength of the strong liquor returning from the absorbers is dependent on the temperature and pressure carried in them. The temperature is determined by the cooling water and will be about ten degrees warmer than the temperature of the water flowing over the absorbers. The absorber pressure will be one or two pounds less than the pressure carried on the brine cooler, and as the

TEMPERATURE, PRESSURE AND CONCENTRATION OF AQUA AMMONIA

%	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
2	169.0	189.4	206.5	220.0	213.1	249.4	264.3	277.9	288.8	299.0	307.8	316.2	323.7	330.7								
4	161.0	180.8	197.5	210.5	221.9	240.3	255.0	267.7	278.9	288.6	297.3	305.6	313.4	320.3								
6	153.0	172.3	188.8	201.5	212.4	229.5	244.0	258.0	169.0	278.5	287.4	295.3	302.6	309.6	316.0	322.2						
8	143.5	164.2	180.1	203.7	221.4	236.0	248.2	259.0	268.5	277.3	285.1	292.5	299.6	305.8	311.6							
10	137.4	154.3	171.1	183.7	194.6	212.3	227.0	239.6	250.5	259.5	267.9	275.8	282.9	289.4	295.7	301.8	307.4	312.6				
12	129.0	147.8	163.1	175.1	185.5	203.3	217.2	229.2	240.0	249.4	258.1	265.6	272.7	279.7	285.6	291.5	297.0	302.2				
14	120.5	140.1	155.5	167.4	177.6	195.2	209.1	220.8	231.2	240.5	248.9	256.1	263.0	269.7	276.0	281.8	287.3	292.4	297.1	302.0		
16	113.0	133.0	147.4	159.3	169.4	187.1	200.5	212.0	222.3	231.6	239.9	247.3	254.0	260.4	266.4	272.2	277.5	282.8	287.3	292.0		
18	107.5	124.9	139.4	151.4	161.2	178.3	192.0	203.1	213.5	222.6	230.9	238.0	244.7	251.0	257.0	262.5	268.0	273.0	277.6	282.4	287.0	291.7
20	99.0	117.3	132.0	143.6	153.8	170.2	183.6	195.4	205.0	213.8	221.8	229.1	235.9	242.0	247.9	253.5	258.6	263.6	268.4	273.3	278.0	282.7
22	92 0	109 9	124.6	139 9	146 0	162.7	175.9	187.0	205.6	213.5	220.6	227.1	133.4	239.3	241.7	250.0	254.9	259.3	263 9	268.5	273 0	273.0
24	86.0	103.0	117.0	129.5	139.2	155.2	168.7	180.0	190.0	198.4	206.0	213.0	219.2	225.5	231.3	236.7	241.9	246.7	251.0	255.5	260.0	264.5
26	79.2	96.3	110.6	122.1	131.9	148.2	161.0	172.1	182.0	190.7	198.2	205.1	211.5	217.6	223.4	228.7	233.7	238.4	243.0	247.2	251.5	255.8
28	73.4	90.6	103.6	115.3	125.0	140.6	154.0	165.2	174.7	182.8	190.3	197.1	203.1	209.3	215.0	220.4	225.5	230.3	234.5	238.9	245.2	241.3
30	66.5	83.8	97.0	108.5	117.8	133.5	146.1	157.0	166.4	174.9	182.7	189.4	195.6	201.3	206.9	212.2	217.3	222.0	226.7	231.1	235.1	239.3
32	61.0	76.9	90.0	101.0	111.0	127.1	139.4	149.7	158.8	167.3	175.0	182.0	188.2	194.0	198.4	204.5	209.4	213.8	217.7	222.0	226.4	230.8
34	55.0	71.6	84.0	94.8	104.5	120.0	132.0	142.4	151.9	160.2	167.8	174.6	180.9	186.6	191.9	197.0	201.7	206.1	210.0	214.2	218.3	322.5
36	49.0	65.5	78.5	88.8	98.1	113.5	125.8	136.0	145.3	153.3	160.7	167.3	173.5	179.3	184.7	189.7	194.5	199.1	202.9	206.8	210.6	214.4
38	43.0	60.0	72.5	83.2	91.8	106.8	119.4	130.0	138.7	146.7	153.8	160.3	166.4	172.2	177.5	182.5	187.3	191.7	195.6	199.3	203.0	206.9
40	37.0	53.8	66.0	77.3	86.0	101.0	112.9	123.4	132.3	140.0	147.0	153.4	159.4	165.0	170.5	175.5	180.1	184.6	188.9	192.8	196.5	200.1
42	31.6	48.7	61.0	71.5	70.4	94.0	106.3	116.4	124.9	132.5	139.8	146.4	152.7	158.2	163.5	168.5	173.3	177.7	181.4	185.3	189.2	193.0
44	27.5	43.2	55.3	65.3	73.6	87.8	100.1	110.3	118.8	126.3	133.2	139.9	146.0	151.5	156.7	161.6	166.3	170.8	174.3	178.2	182.0	185.0
46	21.2	37.6	49.7	59.6	68.1	82.0	94.0	104.2	112.8	120.1	126.9	133.4	139.5	145.0	150.2	155.0	159.4	163.8	167.5	171.3	175.2	179.9
48	16.0	32.0	44.4	54.2	62.7	76.7	88.3	98.5	106.7	114.0	120.6	127.0	132.9	138.4	143.7	148.6	153.3	157.5	161.2	164.9	168.6	172.5
50	11.0	26.8	38.9	48.4	56.8	70.9	82 6	92.6	100.8	108.3	114.9	121.0	126.9	123.4	137.2	142.0	146,4	150.7	154 9	158 7	162.4	166 0

*First column gives per cent concentration; figures in columns are boiling temperatures for the pressure at top of column.

cooler pressure is dependent on the temperature of the brine carried, then the absorber pressure must also be dependent on the brine temperature. The temperature and pressure on the absorbers being thus controlled by these operating conditions, it can be seen that the strength of the strong liquor from the absorber is limited. There is a maximum strength to the strong liquor, and keeping under this strength, the absorber must absorb all the gas coming from the brine cooler and still use a reasonable amount of weak liquor. A strong liquor charge of low concentration means that a high steam pressure on the generator is necessary to drive off the ammonia gas, and a high concentration of the strong liquor charge means that more weak liquor must be circulated, since a smaller amount of vapor is distilled off from a pound of liquor. This increased weak liquor circulation raises the steam consumption. Therefore, with a given water and brine temperature there must be a certain strength of aqua which is the most economical.

Temperature of Strong Liquor

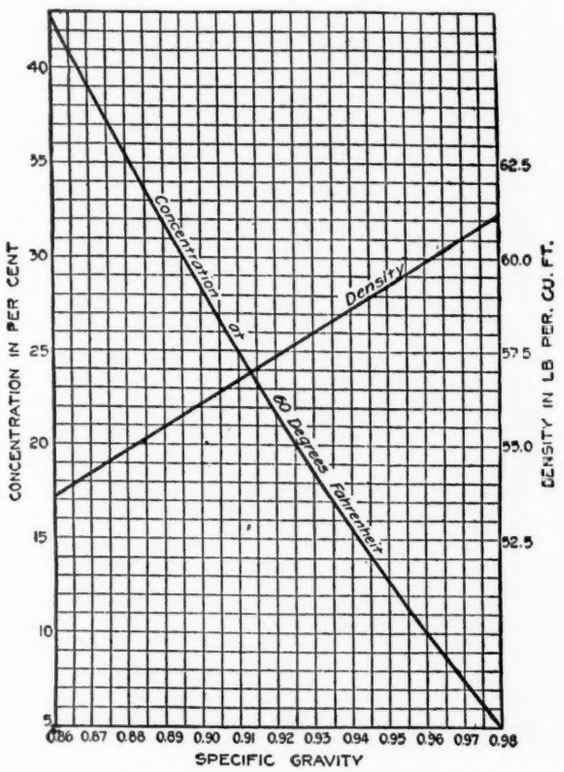
Theoretically, the ideal condition is to have the strong liquor return from the absorbers in a saturated condition, that is, with as high a concentration as it would stand under the existing temperature and pressure; but in actual operation this is not practicable, one reason being that a saturated solution of aqua ammonia is too easily disturbed to give a satisfactory performance of the machine, and another reason being that in operation no absorber is absolutely free from air or foul gas. A satisfactory temperature for strong liquor returning from the absorber is to have it twenty degrees below the boiling point of the solution for the pressure carried. For example, if the strength of the solution was 30 per cent and the absorber pressure was 5 lb. gage (20 lb. absolute), the boiling point taken from the concentration table for ammonia liquor is 97 deg. The strong liquor should return 20 deg. below this or 97 — 20 = 77 deg. F.

For a problem the steam pressure necessary on the generator of an absorption machine carrying zero brine and using 70-deg. condensing water will be determined. As the absorber is the primary factor in determining the steam pressure, it will be examined first. The cooling water will probably be used first on the condenser and raised two degrees, which means the water will go on the absorber at a temperature of 72 deg. With zero brine the pressure carried on the cooler will be about 10 lb. and the absorber pressure will be two pounds lower.

Concentration of Strong Liquor

But as no absorber under operating conditions is absolutely free from foul gas, an allowance must be made. Dalton's law of partial pressures states that when two or more gases are inclosed in a vessel under pressure, the pressure exerted by any one gas is the same as would be exerted by that gas if it were alone. Therefore the 8-lb. absorber pressure will be made up of the pressure exerted by the ammonia gas plus the pressure exerted by the foul gas. Assuming that the pressure exerted by the foul gas was 1 lb., the pressure exerted by the ammonia gas itself must be 7 lb. This is the true ammonia pressure in the absorber. The temperature of the strong liquor leaving the absorber will be ten degrees warmer than the cooling water going on, or 72 + 10 = 82 deg. This 82 deg. must be 20 deg. below the boiling of the strong liquor at the absorber pressure, which gives a boiling point for the strong liquor of 82 + 20 = 102 deg. F. A table on the properties of ammonia liquor will show that liquor that boils at 102 deg. F. and 7 lb. gage pressure contains about 31 per cent of ammonia and has a specific gravity of about 0.97 as shown in the specific-gravity chart. This is the strength of the strong liquor and is the strength to be considered in the generator.

The head pressure with 70-deg. condensing water will be 143.7 lb. gage, as has already been shown. The concentration tables for aqua show that a 31-per cent liquor under a pressure of 144 lb. gage boils at about 218 deg.



SPECIFIC GRAVITY OF AQUA AMMONIA

F. The machine will require the temperature of the steam in the generator steam coils to be 20 deg. higher than the boiling point of the liquor in the generator, or 218 + 20 = 238 deg. From a steam table it is found that to have this temperature, the steam pressure must be 24 lb. absolute, or 9.3 lb. gage, or for practical purposes, say 10 lb. gage.

Ammonia Pump Capacity

Nothing has been said about the weak liquor because it will take care of itself. About 0.6 gal. of strong liquor will be handled by the ammonia pump per minute per ton of refrigeration produced.

By figuring out a table for steam pressures to be carried for different water temperatures and for different brine temperatures, it is easy to understand why the same strength of liquor cannot be carried for different operating conditions. It shows why a weaker aqua solution and a higher steam pressure are required for a cold brine than for a comparatively warm brine. It will also show that the absorption machine can be made to operate satisfactorily on quite warm condensing water notwithstanding the popular belief to the contrary.

The New Waite & Davey Air-Cooled Flat Arch

In addition to the manufacture of air-cooled furnace blocks[1] the Waite & Davey Co., Inc., Long Island City, N. Y., have recently developed an air-cooled flat arch for high temperature furnaces of all kinds.

The arch has been designed with a view to simplifying construction and repairs. It requires no special castings or hangers. All the material necessary for supporting the arch will be found around practically every boiler house or machine shop. The channel iron or I-beams can usually be purchased locally, and this together with the hanger, which can be made from odd lengths of pipe, tends to reduce considerably the cost of the arch.

In Fig. 1 is shown a cross-section of a furnace equipped with an air-cooled flat arch and also air-cooled blocks in the side walls. The advantage of this construction will be readily seen. Air is admitted to the channels in the blocks from the forced-draft air chamber, or where natural or induced draft is employed the air is drawn in through the pipe hangers or other openings provided to the chamber below the grate. By this method the arch is continually cooled and the temperature of the blocks kept well below the softening or fusing point.

An important feature is the simplicity of construction. Each arch unit is hung with pipe hangers with tee connecting ends, to slip into slots made in the blocks, as illustrated in Fig. 2. Tees are used for the connections to allow a free circulation of air. The projecting ends of the pipe hangers are threaded, and the blocks are suspended from channel-iron cross-beams, as shown, by the use of floor flanges and nuts. By this means of

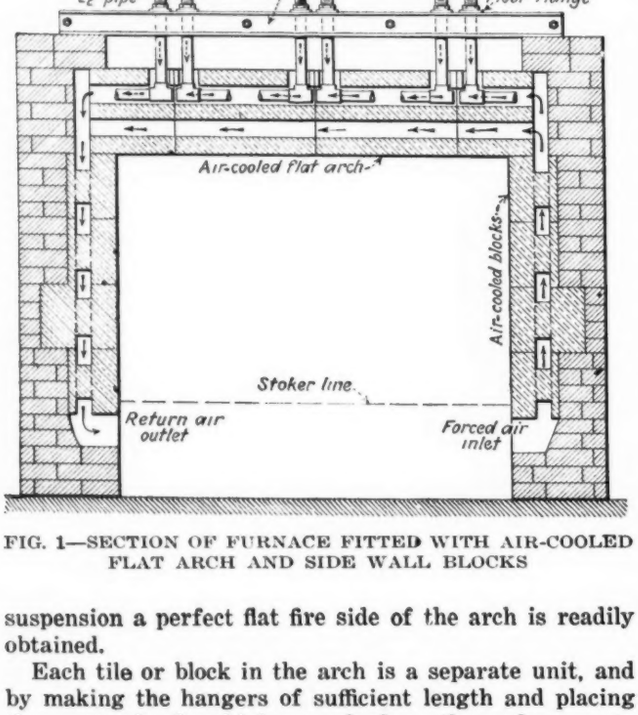


FIG. 1—SECTION OF FURNACE FITTED WITH AIR-COOLED FLAT ARCH AND SIDE WALL BLOCKS

suspension a perfect flat fire side of the arch is readily obtained.

Each tile or block in the arch is a separate unit, and by making the hangers of sufficient length and placing the suspension bar high enough above the arch, any one unit can be readily replaced without cutting the boiler off the line.

[1]See *Power*, July 25, 1922.

The design of the curtain wall, which is one of the important parts of flat-arch construction, is shown in Fig. 2 with a detail of the upper block at *A*. The method of supporting this wall is also clearly shown.

To seal the joints of the arch, asbestos cement or other high-heat resisting materials are used to pack

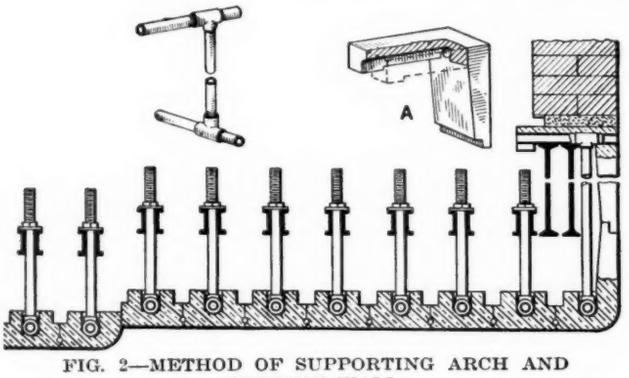


FIG. 2—METHOD OF SUPPORTING ARCH AND CURTAIN WALL

into the grooves made in the arch tiles for this purpose over joints that can easily be removed in case of replacement of an arch unit.

Keeping Track of Details

BY F. P. TERRY

The engineer-in-charge who does not faithfully keep track of the many little details that crop up daily in all plants, will, however "high up," sooner or later find himself superseded, and not without cause. Getting into close touch with all details and keeping posted thereon is one of the items overlooked when the fine position "so-and-so" holds is being discussed, and the fact that much of it cannot be seen or gaged only adds to the importance of the position. Yet the neglect of details is patent to everyone.

Who has not seen the steam hissing out of leaky glands, pipe joints, valves, etc.? Small details, but they loom big against the engineer-in-charge and damn his chance of promotion! In large plants it is usual to delegate many of these details to an assistant, and when this is done it may be said to increase rather than diminish the necessity of keeping track of them. The engineer who packs a gland himself can feel reasonably confident that his workmanship will stay good for a considerable time; he is also certain to remove scores from the rod and see that it is getting proper lubrication; but so long as he is responsible for the work of others, eternal vigilance is necessary on his part.

Most of our successful business men profess that the principal cause of their success was the mastering and keeping continual track of details. We are told to "save the pence, and the pounds will take care of themselves"; the details may be looked upon as the "pence" of the plant. Keep track of the details and the big things will give no trouble. The breaking of one link in a chain is quite enough to cause serious damage, and the neglect of one little detail has wrecked a whole plant. Careful and systematic attention has saved hundreds of plants.

Experiments by the Bureau of Mines, at Grand Forks, N. D., indicate that lignite may be a fuel of great value if it is charred, and perhaps may be used widely for domestic purposes.

EDITORIALS

F. R. LOW, EDITOR

Selection of Coal Versus Care in Storage

THE Bureau of Mines has just issued a valuable report by H. H. Stoek, on "Fires in Steamship Bunker and Cargo Coal." This report and its recommendations are almost as valuable to the power-plant operator in consideration of bunker storage problems as to the man who must select coal or provide for its storage aboard ship. Of the seventeen recommendations given in the summary of the report, almost every one applies directly to power-plant conditions.

This report recognizes the fact that many kinds of bituminous coal may develop spontaneous combustion during storage, but it is pointed out that some are undoubtedly more liable to heating and spontaneous firing than others. The logical conclusion which is emphasized by the report is, therefore: "Hence, when a choice is possible, a coal that, as shown by its past record, is liable to spontaneous combustion should not be put on a ship. If the choice is not possible, and a coal with a bad history must be used, special care should be taken in stowing and watching it." Every one will agree that "in a power-plant bunker or stockpile" might be substituted for "on a ship" in this quotation and the statement would be equally true.

But the more striking feature of the recommendations of the report is the fact that practically all of the summary deals with methods of handling or methods of storage rather than with the selection of the coal. In other words, this author of wide experience in fuel handling seems to have felt that care in management of coal-storage piles is vastly more important than the selection of the coal itself. This is certainly true for most parts of the United States. Almost any of the passable grades of bituminous coal can, when properly handled, be safely stored. It is not equally easy to prevent firing with some of the high-sulphur mid-continent coals which are particularly likely to heat when stored in warm humid climates. But even these more objectionable forms of fuel can be handled with reasonable certainty of safe storage if a little extra care is exercised during storage.

The price of fuel for a power plant depends on the over-all cost throughout a year, all items being included. It is not enough to compare the prices charged f.o.b. the plant siding, nor even this cost plus wastage due to deterioration during handling or storage. The question of likelihood of fire should enter as an element in total cost just as truly as the switching charges, demurrage charge, or "blow-away." And yet the extra care that is necessary to handle a reasonably safe coal, beyond that needed with those varieties that are peculiarly free from the likelihood of firing, is very little. Just because a coal has once given trouble is no reason for abandoning it. It is quite as likely that the fault lay with the yard man who took the easy way for stocking rather than the right way, as it is that the trouble was with the coal itself.

As the time approaches to lay in supplies of fuel, it will be well to figure out how much it costs to handle the coal put in the stockpile in the very best fashion as compared with costs under the slovenly methods, which are usually easier but not materially less expensive. It is more than likely that the extra cost will be simply a little more care in supervision of the work, not any additional money expenditure. And if this is the case, there will be no excuse for paying a bonus for a coal that stocks unusually well, as compared with another that requires a little more care in its handling. If this care costs nothing, it is vastly better to exercise it than to pay out good money unnecessarily, for this expenditure is bound to show on the average fuel cost for the year.

Suiting the Power Plant to the Operator

ONE of the great distinguishing marks of good power-plant design is provision for maintenance, testing, inspection and repair work. This tends to place service continuity on a more certain and economical basis. Rising costs and increasing capacities have made continuity of power production worth almost any price. It pays well to consider the men who make machinery run and cater to their convenience in mechanical matters.

Personal comforts for the repair men, operators and others are not overlooked in large central stations or new private plants, generally. Filtered and cooled drinking water has in many instances replaced the tin cup and bucket, while shower baths often conclude a hot emergency job or a grilling day of ordinary duties. Plenty of daylight in a turbine room is by no means unusual, and clean, well-lighted business-like boiler rooms naturally follow in the wake of modern refinements.

The operator deserves the best of surroundings. By the aid of automatic and semi-automatic devices, one man now controls an immensely greater output than previously. One false step or mistake may do many times the amount of damage previously thought possible. Good surroundings, training, education and discipline are being thoughtfully supplied to employees by many far-seeing executives.

With all that is being done, however, operators in most large plants are subjected to a disagreeable and nerve-racking noise that could and should be avoided. Steam turbines themselves make an undesirable noise, but opening the air outlet of a large generator into the turbine room floods the atmosphere with rasping sound waves. In many large plants conversation is attended with extreme difficulty, and one not accustomed to such annoying sounds, would find it quite impossible to do much deep thinking. The operator becomes used to these conditions, but nevertheless works under a great handicap.

It seems hard to understand why many eminent engineers and executives who visit such noise-filled plants fail to see an adequate reason for improving the situa-

tion. Many perhaps think that excessive noise is essential to turbine operation and perhaps do not realize that a simple change will often remedy matters or at least make conditions much more bearable. Expense can hardly be called an adequate excuse when the cost of the many other safeguards and conveniences is considered. The power plant is far removed from the appearance of a junk yard, but the discord of a boiler shop seems to many a reasonable state of affairs.

When turbine-generator ventilation is carried entirely underground, an observer is seldom annoyed by excessive noise. Allowing the discharge air, however, to flood into the turbine room immediately changes the situation. The advantages of an inclosed ventilating system lie not alone in the suppression of a great amount of noise. By using the system of totally inclosed air, which is alternately heated by the generator and cooled by water or other means as it travels in a continuous cycle of change, immunity from dirt and lessened fire risk are obtained, representing a gain in dollars and cents that counts heavily in offsetting the expenditure.

Danger of Water-Power Development Being Retarded

WHEN the Federal Water Power Act was passed in 1920, after about twenty years of political effort, it became apparent that the most serious difficulties in the way of water-power development had been cleared and that rapid progress would be made toward a wide utilization of our vast water-power resources. That the law, if allowed to operate, would accomplish this is well illustrated by the results.

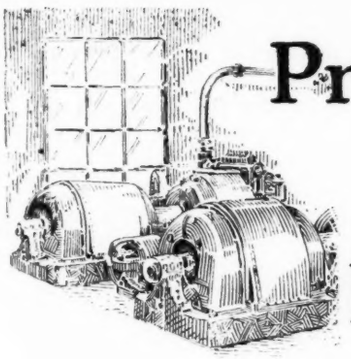
After the creation of the Federal Water Power Commission in November, 1920, it received, up to the beginning of this year, 357 applications for water-power developments aggregating over twenty-one million horsepower. This amounts to more than twice the existing water power developed in this country and more than six times the applications for water-power sites under federal control in the preceding twenty years. During this period the Commission issued sixty-nine final permits and sixty-five licenses, involving installations aggregating five million horsepower. In this respect the country has seen about three hundred per cent more water-power developments than were made under Federal authorization in the twenty years previous to the passage of the Federal Water Power Act. Up to the present time applications for permits have passed the four hundred mark and represent approximately twenty-two and one-half million horsepower. These figures clearly indicate the progress that may be expected in the use of water power if the present law is allowed to control its development. This law was enacted at a time, and has operated through a period, when the country has been sorely tried with the vicissitudes of obtaining a fuel supply and it is turning its attention to water-power developments for relief from these conditions. Great as the progress has been during the last two years and a half, there are indications that our water powers may get into even a worse political tangle than ever before. The state, national and international political complications that have developed during the last two years demonstrate that the enactment of favorable federal legislation is not the only requisite to water-power development.

What has happened at Muscle Shoals, where the development was under federal control, shows that state or international questions are not alone required to create a deadlock on how water power shall be developed and who shall do the developing. Although work is now being done on this development by the government, what final disposition of the project will be made is by no means settled. In New York State, on the one hand, the development of the tremendous water power of the Niagara and St. Lawrence is awaiting a treaty between this country and Canada, and if the progress of the last two years is an indication of the future, more years of waiting may be expected before a satisfactory agreement is worked out. On the other hand, the question of who shall develop water power in the state is awaiting a decision of the United States Supreme Court. Last year, under the leadership of Secretary Hoover as chairman of a commission, a treaty was entered into by the seven states interested in the development of the Colorado River. When this treaty was negotiated, one of the perplexing problems standing in the way of a comprehensive plan, involving about six million horsepower, for power development on this river, was considered solved, but the State of Arizona, by failure to ratify the treaty, has caused this development to be held up. Fortunately, the compact stands and can be ratified at any time in the immediate future. Development on the Columbia River depends upon a tri-state agreement, and other states are divided against themselves regarding a water-power policy to apply within their borders.

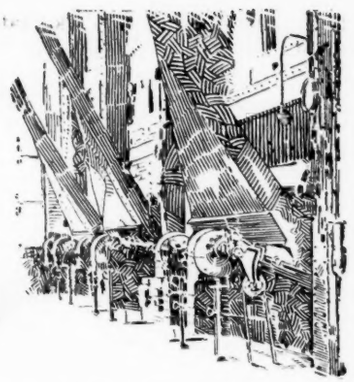
Never was there greater need of united action toward the country's water power. With the use of power increasing at an undreamed of rate, power systems spreading out involving thousands of miles of transmission lines and hundreds of thousands of kilowatts in station capacity, electrification of our railways, the solution of the fuel and transportation problems makes it imperative that the nation's water-power development be made to fit into a comprehensive power scheme. Unless some of the present political tangles are straightened out, they may result in seriously retarding progress in water-power development.

A news item appearing in this issue makes mention of the recent disaster at the Atlantic City (New Jersey) Gas Works, which apparently originated in the boiler room from leaking gas which took fire from the boiler furnaces. As in so many emergencies, there was somebody there on the job, ready to risk his own life to save others. His act was to rush for the main stop valve between the power house and the gas holders and shut off the gas supply. This required much the same sort of heroism as is now and then shown by some engineer who rushes for the throttle of a runaway engine, taking his chance that the flywheel will burst and kill him before he can shut off the valve. All too little recognition is given to the men who perform such deeds.

The American Society of Mechanical Engineers are going to hold their Spring meeting in Montreal this year, and they have invited the Engineering Institute of Canada to attend. This step is one of many that the engineers of both countries are taking to become better acquainted and to learn of the ideals and activities of one another. To develop a whole continent along intelligent and co-operative lines is an object well worth attempting. As neighbors and friends in ideals and interests there can never develop the lack of understanding and of common helpfulness that has created such havoc in Europe.



Practical Ideas *from* Practical Men



Pipe Ends Should Be Reamed

When cutting pipe with a pipe cutter, a ridge is formed on the inside of the pipe, which considerably decreases the inside diameter. It is, therefore, a good practice to ream out after cutting to insure a full pipe opening, a procedure that is seldom followed by a steamfitter except on some special work and when he has been so instructed.

The ridge not only decreases the pipe area, but forms pockets for the deposit of mud, scale, etc. It also increases the friction of flow, which is no small item on long lines.

It may take a little longer to ream the pipe, but if a part of the time that is often spent on the outside, were spent in improving the looks of the inside, better results would be obtained. R. G. SPOONER.

New Bedford, Mass.

Repair of Oil-Engine Fuel Pump

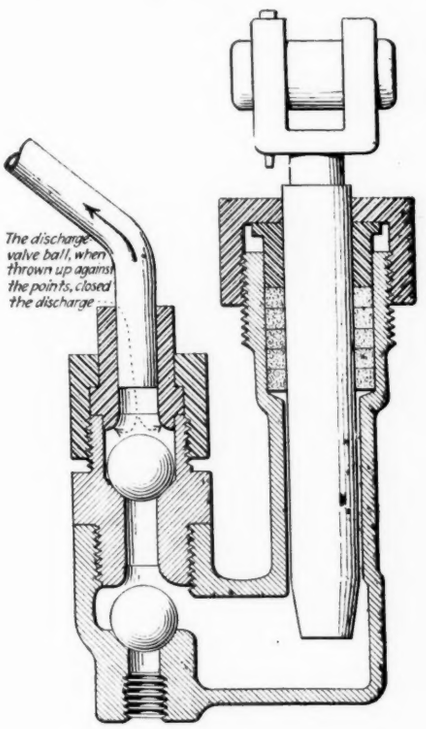
After operating two semi-Diesel engines for a year, I began to feel that their peculiarities were thoroughly understood, but to my surprise one of them suddenly began to miss firing. This was found to be caused by lack of fuel, accompanied by an increasing leak and drip from the fuel pump. The governor acted queerly too, the engine hitting hard a few times and then quitting, exactly as though equipped with "hit-and-miss" control.

The fuel pump, which lifted the fuel from the storage tank and delivered it to a small reservoir from which the injection pump obtained its supply, was repacked to stop the leak, but the plunger would promptly tear the packing. All sorts of packing were tried, tin foil in combination with fibrous material serving best, but nothing lasted long. At last one of the makers' erectors suggested the trouble.

The discharge valve of the fuel pump consisted of a brass ball on a spherical brass seat, as shown in the illustration. The ball in its raised discharge position came against a check seat in which large slots were cut, so that the ball upon lifting would not close the discharge. After two years' running, this ball had battered the check seat above it so as to close the slots. Thus the ball, rising from its own seat, would strike the seat above it and, since the slots had disappeared, would stop the discharge of oil. The plunger, driven by the whole power of the engine, would raise the pressure in the pump cylinder to a very high value, which in turn would cause the governor weight to be thrown out to its farthest position. This shortened the stroke of the injection pump, which was driven by the same rocker, and caused a light explosion. The engine would fall off in speed, the governor would give the rocker arm more throw, and for a few moments there would be heavy explosions in the engine cylinder. Then the increased travel of the pump plunger would throw the discharge ball high enough to close the outlet, and the missing would repeat. The trouble was solved by cutting new slots in the check seat.

Another case of irregular governing gave much trouble. The cause could not be discovered until the engine stopped, when it was found that the rocker arm was seized, although the attendant said he had oiled it regularly. This rocker arm was one of the two points on the engine whose lubrication seemed inadequate, the other being the governor weight pin. The rocker arm was provided with an open oil boat on top and was arranged to be oiled through two tiny holes. For a piece in constant motion twenty-four hours a day, transmitting considerable thrust, and absolutely vital, this seemed inadequate and was the cause of much trouble. COLIN K. LEE.

Bowling Green, Mo.



FUEL PUMP FAILED TO WORK

Determining the Pressure-Drop Through a Boiler

It is comparatively easy to determine the loss in pressure between the boiler drum and the turbine throttle, but to determine what fraction of this loss occurs in the boiler and how it is distributed through the various parts is not so easy. It is difficult and expensive to make the necessary preparations, such as drilling and tapping holes, calibrating and connecting gages, etc. Besides, after the loss is determined, it is doubtful if anything could be done to cut it down. Therefore in a commercial boiler room a test of this kind would be a comparative rarity.

In a certain plant it had been known for a long time that at high rates of steaming the pressure drop between the boiler drums and the turbine throttles was excessive, and that the greater part of this drop was between the drums and the main steam header. At the same time the temperature of the steam at the throttle was considerably above the maximum allowable temperature for the metal of the steam chests and

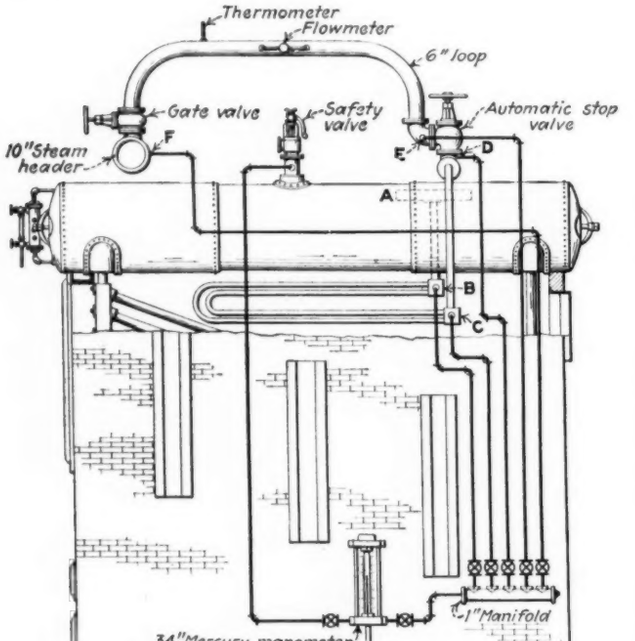


FIG. 1—ARRANGEMENT OF PIPING CONNECTIONS BETWEEN BOILER AND MANOMETER

valves. As it was getting increasingly difficult to keep the valves in operating condition, a test was determined upon to ascertain the actual pressure drop in the boiler, the actual superheat delivered and, if possible, to find some way of decreasing one or both.

The boiler under test was a horizontal water-tube with three 42-in. drums, 21 tubes wide and 12 high, and having approximately 5,000 sq.ft. of heating surface. The operating pressure was 200 lb. gage. The superheater was of standard make, using a single bend with core pipes and designed to deliver 125 deg. F. superheat. The steam from the drums to the superheater cross-box was through three 4-in. connections; from the superheater to the cross-box below the stop valve, through three 4-in. bends; from the automatic stop valve to header, through a 6-in. pipe with two long-radius bends and a straightaway of ten feet and a 6-in. gate valve directly above the header. In the straight piece was located the thermometer well and flow-meter nozzle.

After experimenting with test gages placed at various points and thereby realizing the difficulty of getting accurate and simultaneous readings from all points at once, it was decided to connect these points to a manifold and by means of a mercury manometer the actual pressure drop between any two points could be obtained instantly. As shown in Fig. 1, a manifold was made

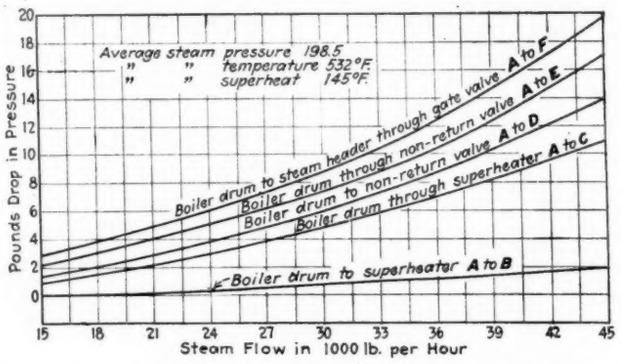


FIG. 2—SHOWS DROP IN PRESSURE THROUGH BOILER AT DIFFERENT RATINGS

out of 1-in. fittings and connected through ¼-in. pipes and the necessary valves to the manometer, the two superheater cross-boxes, the inlet and outlet of the stop valve and the main 10-in. header. The other side of the manometer was connected to the cross-box under the safety valves.

Readings on the manometer were taken when the flow-meter read 15,000 lb. per hour, 100 per cent rating, and thereafter at every 3,000 lb. increase up to 45,000 lb. per hour, or 300 per cent rating. Owing to the flexibility of the stoker control no trouble was experienced in getting any of the ratings mentioned and maintaining it practically constant while the readings were being made.

All readings were corrected for variation of height of water column converted from inches of mercury to pounds per square inch and the results plotted, using pounds drop in pressure as ordinates and pounds steam per hour as abscissas, as shown by the chart, Fig. 2. Each curve gives the total drop in pounds from the boiler drum to the fitting named. Therefore the vertical distances between curves on any particular rating gives the drop in pressure through the individual parts. For example, at 30,000 lb. rating the drop through leads to superheater is about 1 lb., through superheater alone about 4 lb., and about 1 lb. through each of the other fittings.

It will be noticed that the drop through the superheater is almost one-half the total drop through the entire boiler. This is more evident along toward the higher ratings. The average superheat was 145 deg. F. about 20 deg. higher than for what the turbines were designed. It was therefore determined to remove the core pipes from the lower half of the superheater, thus reducing the pressure-drop considerably, as well as the superheat.

The actual reduction in superheat and drop in pressure, due to the changes mentioned, has not been determined up to the present writing.

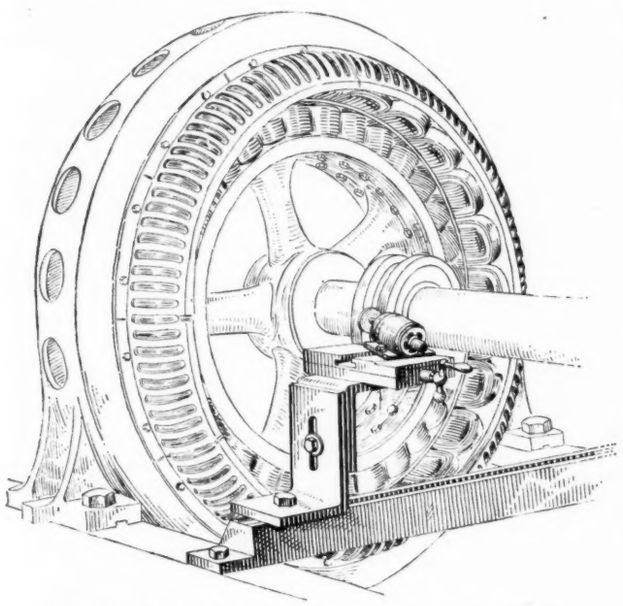
L. P. ALFRED.

Cleveland, Ohio.

Grinding Collector Rings

The collector rings on a large alternator became worn so that trouble ensued due to jumping of the brushes. In order to true them up as quickly as possible, the master mechanic of the plant decided to turn them off without removal.

With odds and ends found around the shop, he rigged up a stand, borrowed a cross-feed from a lathe and



GRINDER MOUNTED FOR TRUING SLIP RINGS

proceeded to turn down the rings. He found it impossible to make a tool cut the surface of the rings smoothly, and decided to grind them, which was done in the manner shown in the figure. Two angles were bolted together and fastened to the cross-beam that carries the stand for the brushes. On the upper angle iron the cross-feed of a small lathe was bolted. A small electric grinder was fastened to the cross-feed, which was adjusted so that the grinding wheel was fed across the face of the collector rings when the feed screw was turned. It will be seen that the grinder is set at an angle. This was done so that the shell of the motor would clear the collector rings.

This method produced a mirror-like finish on the face of the rings. R. H. KASPER.

Philadelphia, Pa.

Reducing the Temperature of Heating Returns

Considerable trouble is sometimes encountered in the operation of vacuum return heating systems by the vacuum pump's becoming vapor-bound. To overcome this difficulty, it is usual to tap a cold-water line into the vacuum-pump suction to condense the vapor that is formed; at the same time this is a convenient way of introducing the necessary makeup feed water to the system. However, when the makeup water required is less than the amount necessary to keep the vapor down in the vacuum pump, it will be necessary to let the excess run to waste. Since the temperature of this water has been raised from around 100 to 150 deg. F. this will involve considerable loss of heat, depending of course on the amount of water so wasted, and especially more so in those plants where all the returns are pumped directly to the heater and the excess water discharged to the sewer at feed-water temperature.

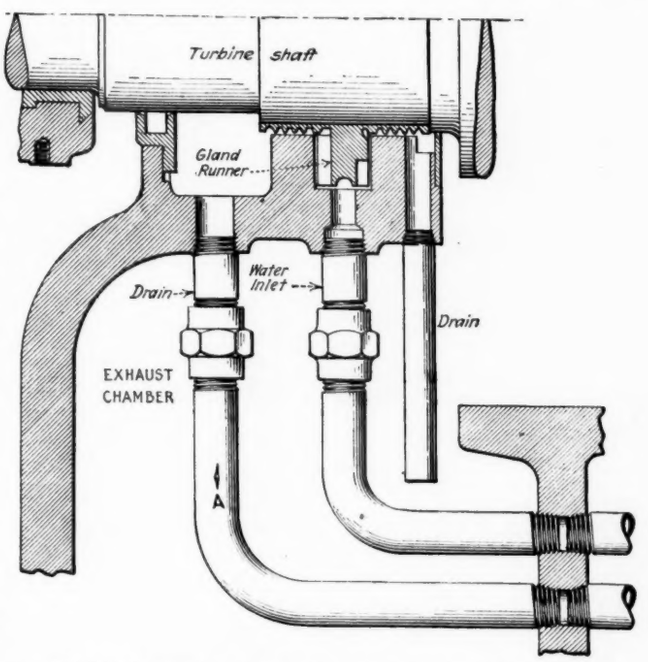
In some plants, especially those serving hotels, hospitals, office buildings, etc., there is a considerable demand for hot water, for which an independent service heater is provided; the losses mentioned may be avoided by making use of a heat exchanger where the cold water going to the service heater absorbs heat from the hot returns before entering the vacuum pump, thereby reducing the temperature considerably and thus preventing the formation of vapor. For this purpose a small closed heater, surface condenser, or double-pipe cooler will fulfill the requirements.

Chicago, Ill. JULIUS BRODSKY.

Corrosion of Gland Drain Pipe Causes Drop in Vacuum

Recently we experienced trouble in maintaining the vacuum on our 1,250-kva. turbine, which exhausts to a barometric condenser.

The vacuum went down very gradually till at the end of three weeks it had dropped from 28 to 24½ in. We had looked over the machine and condenser several times for evidence of an air leak, but without success; so we finally decided to remove the cylinder cover, expecting to find the water-seal glands clogged with scale. To our surprise they were clean, but while examining the joints and piping in the exhaust chamber, we discovered the trouble. The waste pipe from the low-



ARRANGEMENT OF GLAND AND PIPE CONNECTIONS

pressure seal had corroded through, as indicated at *A* in the illustration. This pipe passed through the exhaust chamber and was open to the atmosphere at both ends. The hole had slowly enlarged, admitting sufficient air to lower the vacuum to the point mentioned. After this section of pipe had been renewed, the vacuum returned to normal. W. A. MCELROY.

Morgantown, W. Va.

Comments from Readers

Impurities Passing Over with Steam

O. R. McBride, in the April 10 issue, in commenting upon my article on boiler inspecting in the Feb. 27 issue, criticizes the statement made therein: "Bear in mind that impurities contained in feed water are never carried over with the steam.

I thank Mr. McBride for calling attention to this statement, which might be qualified somewhat. It was the intention to say that aside from a few volatile substances, chemical salts are not carried over with the steam. To be sure, under some conditions, impurities may be carried over mechanically with steam, but never chemically, which was the thought in making the statement in question. JAMES F. HOBART.

Dunedin, Fla.

Preventing Sparking at Brushes

I read with interest the articles on "Preventing Sparking at Brushes," by P. Bumpus in the Feb. 27 issue, and by R. G. Spooner and F. E. Myers in the March 27 issue. I agree with Mr. Spooner that with the generator properly balanced, the commutator ground to a smooth surface and polished, the proper grade of brushes and correct tension adjustment on the springs, sparking at the brushes will be negligible.

In my experience applying oil to the commutator has been only a temporary relief. I have found that with an abrasive brush the wear on the commutator has been excessive, especially on the soft bars; this causes low spots, and consequently further trouble. With flush mica commutators I have found that a brush that is slightly abrasive gives good results, but with undercut mica a non-abrasive brush is best.

My advice is to use the proper brush for the particular type of machine, keep the commutator ground and polished to a good surface, and use no oil or vaseline. If sparking still continues, look for internal trouble in the armature. L. E. MANG.

Tarentum, Pa.

What Causes the Pump To Groan?

We recently completed overhauling a 3,000,000-gal. duplex pump, and since putting it into service it has made a groaning sound.

The water end of the pump was in bad condition, the walls of the water cylinder being badly scored. The bore of the pump was 17 in. in diameter and the plunger 12½ in. in diameter, which caused us to use a lubricated braided flax packing 2¼ in. thick, which we found could not be kept watertight, and the leak aggravated the bad condition already existing.

We installed a brass sleeve in the pump and reduced the bore to 15½ in. We also put a brass sleeve on the plunger, and increased it to 13¼ in. in diameter. We are now using a 1-in. square packing consisting of 1-in. hydraulic alternating with 1-in. pure rubber. It was at first thought that this might be causing the trouble, so we took out the rubber ring and substituted flax, but this apparently made no difference.

In reality the pump is working splendidly, pumping more water with less fuel, but there is a groaning, scraping sound in the water cylinders which seems to be on one side when the plunger is going ahead and on the opposite side when the plunger is pulling back.

The steam end of the pump operates condensing on about 24 in. vacuum, and the suction on the pump varies from about 2 ft. above the pump to about 17 in. well vacuum.

We tried the pump with the cylinder heads off, and it ran quietly, but as soon as the heads were replaced the trouble recurred.

Possibly some readers of *Power* have had a similar experience and could suggest the cause of the noise and a way to overcome it. P. STEWART.

Albuquerque, Trinidad.

How Should Boilers Be Rated?

There is a growing tendency to drop the old confusing term "horsepower" as a measure of the size of a boiler and to use the number of square feet of heating surface instead. We read "There will be four 12,500-square-foot boilers" instead of "there will be four 1,250-horsepower boilers," as formerly.

But is heating surface a fair and accurate means for indicating boiler capacity? We know that depends on several things. For instance, take a boiler that has 10,000 sq.ft. of heating surface. It was sold as a "1,000-hp. boiler." It has about 8,500 sq.ft. of tubes in the path of the gases and has only about half of the lower rows of tubes exposed to the radiant heat of the furnace. The remaining 1,500 sq.ft. is in the circulating tubes, part of the drums and tube headers. Most of this surface is out of the path of the gases and in dead pockets. If it were all thoroughly insulated with asbestos, no doubt carefully conducted tests would show a slight difference in capacity and efficiency of the boiler. So it does not follow that if two boilers have the same heating surface the capacities and efficiencies will be equal.

It would appear that pounds of water per hour evaporated into steam is the better yardstick. That is what it comes to, finally, so why not bring it in at the start and save confusion? Of course, on large jobs this is all well taken care of, for all are engineers. But confusion creeps in when the buyer has not had technical training enough to thread his way through this horsepower-of-two-different-kinds and per-cent-of-rating labyrinth. I am familiar with a case where a boiler was purchased on a "horsepower" basis. The stoker, fan, etc., were selected of sizes to run the boiler at "200 per cent of rating." It was shortly found that the draft loss through the boiler was excessive at about "150 per cent of rating" and priming and flashing occurred when this limit was exceeded. The engineer representing the

boiler company seriously protested to the purchaser against operating the boiler under what he called "heavy overloads." He got away with it to the extent that final payment on the boiler was made.

Reputable boiler manufacturers are willing to guarantee that their boilers will be capable of evaporating certain amounts of water per hour into steam under the given conditions. This is the only boiler rating that really means anything definite to the purchaser.

Lansing, Mich. J. R. BELKNAP.

Motorizing a Three-Phase 600-Kva. Alternating-Current, Engine-Driven Generator

Referring to the letter by Marshall L. Barker in the April 3 issue, on "Motorizing a Three-Phase 600-Kva. Alternating-Current Engine-Driven Generator" while testing a condenser for leakage, in my opinion the air pump should be independently steam or motor driven if for no other purpose than to use vacuum on the condenser for finding air leaks by the use of the candle. It has been my experience that failures continually occur in condenser tubes, and it is rather expensive to have to use 100 kw. for finding leaky tubes.

Mr. Barker asks if the engine could have been started from a standstill without additional switchboard equipment. If the plant is equipped with two sets of busbars and more than one unit of nearly the same capacity, the machines could be connected to the auxiliary busbar and let the transmission line furnish the power for the required plant load.

By switching to the auxiliary busbar with the extra unit, he could lower the voltage to one-half of the rated voltage. Speed should be kept up to normal and the generator switch closed on the 600-kva. machine, and as the machine comes up to speed, which takes about 15 seconds, the field switch should be closed and the voltage on the running machine raised to normal, finally adjusting the field current on the motorized machine to normal. This acts the same as an auto starter. Just as the switch is closed on the motorized generator, the driving generator will show a high ampere reading, but it lasts only a few seconds and comes back to zero as the machine comes up to speed.

On long transmission lines, where power is furnished at different points and some of the plants run more economically than others, it is common practice with steam-turbine units to have one or more in on the line with the steam shut off. This is done to raise the power factor and the line voltage; the generators operating as synchronous condensers.

The same holds good for water-driven generators. Where the water runs short, the generators are left connected to the line with the turbine gates closed, and by carrying full field current on the motorized generators the loaded machine operates nearer unity power factor.

I have been through these different operations as far back as 1910, and on several occasions I have started a 750-kva. frequency changer set from a standstill with a 300-kva. generator, and also a 2,500-kva. frequency changer set with a 2,000-kw. steam turbine by the process described.

In large stations, where there is around a 75 per cent load change in five to ten minutes and a number of units are on the line, it is good policy to have some of the governors set a little slow and sluggish, and as the load drops the majority of the generators will be motoring instead of all trying to carry a small part of the load. This is the best method of operation.

Rockford, Ill. C. M. WESTCOTT.

Referring to Mr. Barker's question, I feel sure that the alternator would not have started unless it had solid field poles or a heavy damper winding in them. Undoubtedly, the field poles of the alternator were laminated, but in any event it would have been poor practice to apply full voltage to the alternator when at rest. The alternator would have to act as a squirrel-cage motor on starting, and when full voltage was applied it would draw nearly nine times normal current, which in this case would take nearly 5,400 kva. from the line at a low lagging power factor; this would act like a short-circuit and probably open a circuit breaker somewhere in the system or at least cause considerable disturbance and possibly damage to the alternator.

A single- or two-phase machine would have worked as well as the three-phase machine, but a single-phase machine cannot be started from the electrical end, as it produces an oscillating torque instead of a rotating torque as in a polyphase machine.

This recalls an instance which occurred in our plant some time ago. Full voltage was accidentally applied to a 500-kw. 6,600-volt synchronous motor without any preliminary switching, when at rest. When the switch was closed, there was a report equal to that of a shotgun being discharged, and the machine came up to speed in about ten seconds, while a large cloud of dust emerged from it. No physical damage was done, but I feel sure that if this method were frequently practiced disastrous results would eventually occur to the machine or its equipment. E. B. HEISE.

Michigan City, Ind.

Motorizing an alternating-current generator is quite common practice in small power stations operated by mining companies in connection with their mills. The generator is usually connected to the lineshaft of the mill, which is driven by water power, the generator being operated in parallel with the local power company's system. During the time of year when water is plentiful, the generator furnishes current to the line, but during the winter months it is used as a motor to drive the mill, taking power from the public-utility transmission line.

In starting, all the load is taken off the lineshaft with the exception of the generator. There is always enough water to bring the generator up to speed, and after switching in on the line, the necessary adjustments are made to use all available water, the generator either delivering current or taking it, as the mill load is connected to the lineshaft.

Mr. Barker also asks if a two-phase or single-phase machine would have acted the same as his three-phase machine. They would as long as they were not loaded beyond their capacity.

A direct-current, shunt-wound generator would also act the same except, possibly, for a slight change in speed, while on a series-wound machine the field leads would have to be reversed.

It follows, therefore, that a compound-wound direct-current generator would not operate as a motor until the field connections were changed to bring about the proper relation between the series and shunt fields.

Telluride, Colo. C. C. HORN.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Reduction of Grate Area for Less Boiler Capacity

What changes should be made in a water-tube boiler of 2,500 sq.ft. of heating surface, with grates 9 ft. wide by 7 ft. deep, to operate the boiler at about one-third its rated capacity? S. L.

Fair results should be obtained by stopping off about one-half of the grate and ashpit areas with a 24-in. bridge wall and 16-in. side walls, with the latter raised 24 in. above the grate level, leaving the furnace and ashpit each 6 ft. 4 in. wide and 5 ft. deep. This should make the width of furnace and ashpit greater than the distance over the fire and ashpit doors, but if that is not the case, the faces of the side walls could be splayed at the front ends to clear the door openings.

Setting Corliss Valves for Compression

With a Corliss valve gear how can higher compression be obtained? L. G. T.

Higher compression is to be obtained by having the exhaust valves close earlier, and that can be accomplished by advancing the eccentric; or by adjusting the length of the exhaust valve rods so those valves will have more lap when the wristplate is in central position; or by combination of those adjustments. However, by advancing the eccentric, all events controlled by it occur earlier in the stroke; consequently, there would be earlier release as well as earlier compression and, with a single eccentric for operation of the steam as well as the exhaust valves, without adjustment of valve rods the steam lead would be increased and the range of cutoff would be decreased. If earlier compression is obtained by simply adjusting the exhaust-valve rods, it results also in later release and in reducing the amount that the exhaust ports are uncovered.

If it is desired to have release and beginning of compression at the same fraction of the admission and exhaust strokes, first see that the exhaust-valve rods are adjusted so the laps of those valves will be zero when the wristplate is in central position; then with the wristplate hooked up, place the crosshead at that point of the stroke where compression and release are to begin and set the eccentric at such angle of advance that the exhaust valves will be just closed.

But if it is desired to have compression begin at an earlier point in the exhaust stroke than release begins in the admission stroke, the exhaust valves must have lap, and for release to occur before the end of the admission stroke, the eccentric must be in advance of its 90-deg. position. For these purposes first set the valves without lap when the wristplate is central; make a mark on the crosshead and for each end make corresponding marks on the guide when the piston stands at the desired points for beginning of release and compression; locate a middle mark between these marks at each end, hook up the wristplate, turn the engine over until the crosshead mark corresponds with the mark for release at one end, turn the eccentric around on the shaft in the direction of rotation and temporarily set it at the point where the exhaust valve of the other end begins to open. Then turn the engine forward until the same exhaust valve should be closed for the beginning of compression, and close up half of the remaining port opening by adjustment of the length of the valve rod. Then turn the engine over to the first point of stroke where the valve should begin to open for release and set the eccentric forward to a position where the valve is just beginning to open. Next turn the engine over to the position where the other exhaust valve should be closed for the beginning of compression and adjust its valve rod to the proper length for just closing that valve.

With a single-eccentric engine, after the setting of the eccentric has been adapted to the setting of the exhaust valves, have the wristplate hooked up with the eccentric and, with the engine turned first on one center and then the other, adjust the rod of each steam valve to obtain the desired lead.

Selection of Circulating Pump

How are the net power required and capacity of a pump figured for circulating cold drinking water in a large building? V. E. K.

The quantity of water to be handled depends mainly on the rapidity of circulation that is desired. For instance, if the circulating system holds 500 gal. of water and circulation is to take place at such velocity that all water is to be returned once in 10 min., then for circulation alone the capacity of pump would have to be 50 gal. per min.; and if the draft of water at drinking fountains, faucets, etc., at any time amounts to as much as 5 gal. per min., the pump capacity should be 55 gal. per min. The power required depends on the height to which the water where drawn would have to be elevated above the supply to the pump, and the pipe friction of the circulating system. The weight in pounds of water drawn per minute at any faucet, multiplied by the head in feed at which it is drawn above the head of the supply to the pump, would be the number of foot-pounds per minute required for delivery to that particular faucet while it is in use. It would be well to assume that all outlets may be in use at the same time.

The power required to overcome pipe friction would depend on the size and length of circulating pipes and the quantity of water circulated per minute. In estimating the power required to perform the circulation.

no account need be taken of the height of the building, because it is assumed that the system is to be kept filled, and the static pressure of the return flow would balance the pressure in the rising pipes, requiring of the pump nothing more than to overcome the pipe friction and power required to supply the drafts at faucets and drinking fountains. For most situations a suitable motor-driven pump would have an over-all efficiency of about 50 per cent.

Transmission Capacity and Length of Belt

What number of horsepower would be transmitted by a 21-in. double leather belt from a 12-ft. diameter engine pulley running 105 r.p.m. to a 25-in. diameter iron generator pulley, with the pulley centers at the same level and the under side of the belt pulling; would an idler pulley be needed; and what length of belt would be required? E. S.

With the pulley centers at the same level and bottom belt pulling as shown in the figure, an open belt without the use of an idler would obtain about 157½ deg. contact on the generator pulley without allowing for greater contact that would result from sag of the slack side of the belt. From an open double leather belt of average quality, made up endless, a load conservative of reasonable durability would be taken in the proportion of 2 hp. per inch of width running on a 30-in. diameter pulley at 100 r.p.m., which would allow for the belt in question a transmissive capacity of $\frac{2\ (12 \times 12)\ 105}{30 \times 100} \times 21 = 211.7$ hp., or about 161 kw. By use of an idler tightener this could be increased upward of 25 per cent, but not without taxing the durability of the belt.

The length of open belt without allowance for sag would be practically equal to the sum of the semicircumferences *ABC* and *DEF* and the equal lengths *AF* and *CD*, taken between the points on the circumferences of the pulleys where they are intersected by their vertical center lines *AC* and *FD*. Drawing *GF* parallel to *HJ* gives the right-angle triangle *AGF* with base *GF* = 25 ft., or 300 in., and perpedicular *GA* = radius of the larger pulley less the radius of the smaller pulley, or 72 in. — 12.5 in. = 59.5 in. Hence $AF = \sqrt{(300)^2 + (59.5)^2} = 305.84$ inches.

As the semicircumference *ABC* = ½ of 144 × 3.1416 = 226.19 in., and the semicircumference *FED* = ½ of 25 × 3.1416 = 39.27 in., the total length of belt *AF* + *CD* + *ABC* + *FED* thus determined would be 2 × 305.84 + 226.19 + 39.27 = 877.14 in. = 73 ft., 1.14 in. or about 73 ft. 1⅛ in., and allowing a belt thickness of ½ in. the length around the center of the belt would be 1.5 more or 73 ft. 2⅝ in.

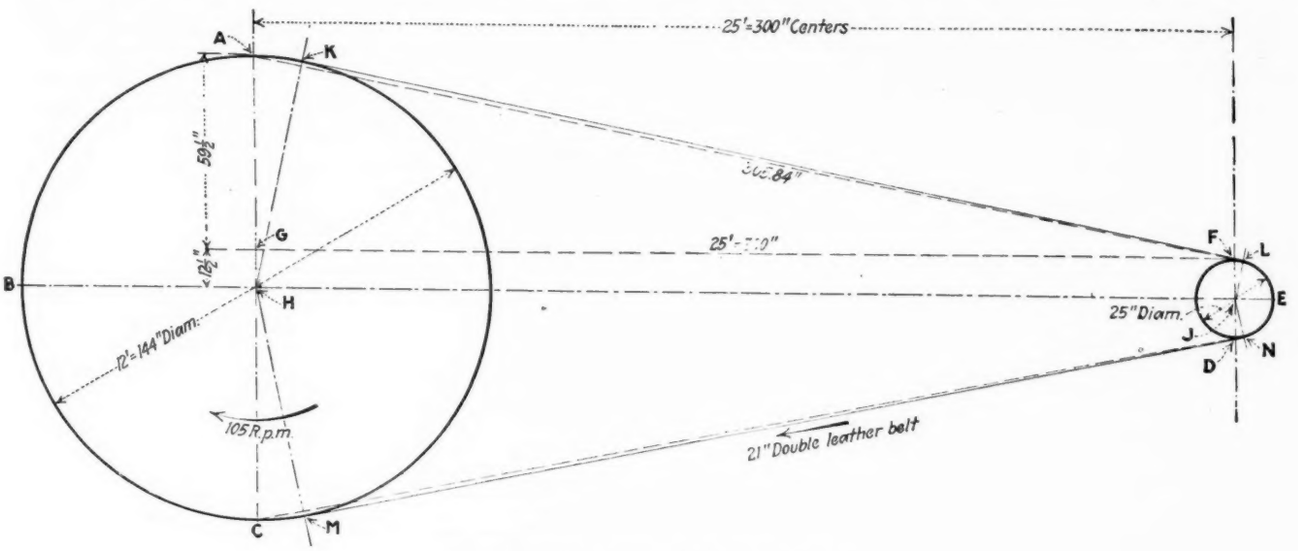
From making computation of the actual tangential lengths *KL* and *MN* and actual arcs of contact *KABCM* and *LEND*, the total length so found would be only about ¼ in. more.

Chloride of Calcium Solution per Gallon of Water

If one gallon of water is used to make a 21 per cent chloride of calcium solution, what would be the number of gallons of solution? M. P. T.

A "21 per cent calcium chloride solution" means that the solution consists of 21 parts by weight of calcium chloride and 79 parts by weight of water. Allowing that the specific gravity of such a solution is 1.18, a gallon of the solution would weigh 1.18 times as much as a gallon of water. As a gallon of water weighs 8.33 lb., to make a 21 per cent solution with a gallon of water, there would be 8.33 lb. of water representing 79 per cent of the weight, so that 1 per cent of the weight would be 8.33 ÷ 79 = 0.1055 lb., and 21 per cent of calcium chloride to be added would weigh 0.1055 × 21 = 2.2155 pounds.

Hence the total weight would be 8.33 lb. of water plus 2.2155 lb. of calcium chloride = 10.5455 lb. of the solution. Then, as the specific gravity of the solution would be 1.18 times that of water, the volume would be the same as the volume of 10.5455 ÷ 1.18 = 8.93 lb. of water, and since one gallon of water weighs 8.33 lb., the solution would have a volume of 8.93 ÷ 8.33 = 1.07 gallons.



ESTIMATING LENGTH OF OPEN BELT

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering

The Slide Rule—I. Reading the Scales; Multiplication and Division

The purpose of this article is to explain briefly how to read the principal scales of a slide rule and how to use them for multiplication and division.

Fig. 1 shows the general appearance of such a rule and gives the names of the principal parts. Four scales

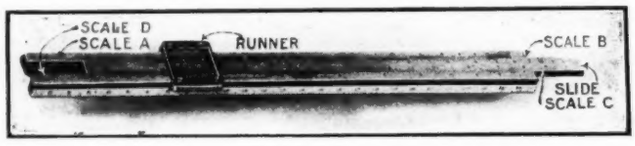


FIG. 1—TYPICAL SLIDE RULE SHOWING PRINCIPAL PARTS

are shown. On the top edge of the body of the rule is a scale *A* in contact with an exactly similar scale *B* on the top edge of the slide. On the bottom edge of the slide is another scale *C* in contact with an exactly similar scale *D* on the body of the rule.

The first step is to learn to read these scales. Fig. 2 shows the *A* and *D* scales of the rule, the slide and runner having been removed to avoid confusion. The length of these scales is ordinarily 10 in., a little larger than shown. Taking scale *D* first, and considering only numbers between 1 and 10, 1 is at *a*, 2 at *f*, 3 at *n*, 4 at *r* etc., and 10 at *z*. The last point is marked simply "1" because, as will later be explained more fully, no attention is paid to the decimal point in most slide-rule operations, and "1" is the same as "10" except for the decimal point. Between any two successive first-place divisions are ten second-place divisions. Between 1.0 and 2.0 the second-place figures are marked, 1.3 coming at *b* and 1.8 at *d*. Elsewhere the second-place figures must be located by counting. So 2.5 comes at *k*, 2.7 at *l*, 2.2 at *g*, 3.4 at *p*, 4.7 at *s* and 7.2 at *v*.

One-tenth of the distance between any two successive second-place graduations represents a unit in the third place of figures. At the left end of the scale, from 1.00 to 2.00, there is a graduation for each third-place unit, 1.47 coming at *c* and 1.84 at *e*. As we move toward the right, the first- and second-place graduations keep getting closer together so that it soon becomes impracticable to put in all the third-place graduations. From 2.00 to 4.00 the second-place spaces are divided into fifths, 2.42 coming at *h*, 2.44 at *i*, 2.46 at *j*, etc. So 2.75 comes at *m*, 3.28 at *o* and 3.93 at *q*. Above 4.00 there is only room to divide the second-place spaces in half, so that 4.70 is at *s*, 4.75 at *t*, 6.49 at *u*, 8.32 at *x* and 9.38 at *y*. With practice one should be able to estimate to the nearest unit in the third place of figures anywhere on the *D* scale. At the left end of the scale the greater spaces make it possible to estimate the fourth place.

The *A* scale is like two *D* scales placed end on end and compressed to the length of one *D* scale. The first- and second-place graduations are exactly the same as those on the *D* scale except that they are closer together. This leaves less room for third-place graduations, so that between 1.00 and 2.00 the third-place divisions go by steps of 0.02, between 2.00 and 5.00 by steps of 0.05, and between 5.00 and 10.00 (marked "1") are omitted altogether. No attempt should be made to memorize these divisions. Merely notice how they are running in the particular section of the rule that is being read. For practice take a sheet of paper and write down the readings corresponding to the various points marked on the *A* scale. Then check the readings by the following: $b = 1.4$, $i = 1.4$, $d = 1.87$, $j = 1.93$, $c = 1.685$, $e = 2.96$, $k = 4.66$, $f = 5.83$, $l = 8.62$, $g = 8.83$, $a = 1.10$, $h = 1.01$.

Now put back the slide and runner noting that scale

FIG. 2—SLIDE HAS BEEN REMOVED TO SIMPLIFY READING OF *A* AND *D* SCALES

B is exactly like *A* and scale *C* exactly like *D*. The beginning or end of any of the four scales is called an "index." The same name applies to the center point (marked "1") of the *A* and *B* scales. The runner (with a vertical line scratched on the glass) is merely a marker used to hold a place or assist in reading the scale.

The following rules apply to either the *A* and *B* pair

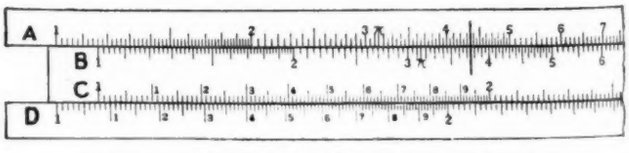


FIG. 3—MULTIPLICATION OF 116 BY 3.75 ON *A* AND *B* SCALES

of scales or the *C* and *D* pair. Wherever the word "index" is mentioned, any convenient index may be used. Moreover, in the *A* and *B* scales the numbers may be read on either the left or right halves. Sometimes, however, the answer will come off the scale when using a certain index and half of the scale (particularly with

the *C* and *D* scales). When this occurs, another combination should be tried. After experience with the rule the operator will usually be able to start with a combination that will bring the answer on the scale.

Rule 1—Decimal Points: No matter where the decimal points may be in the actual numbers, read them on the rule as if they were numbers between 1 and 10. After the figures of the answer have been obtained, locate the decimal point by a rough mental calculation.

If 52.5 were multiplied by 0.012 on the slide rule, we would proceed as if multiplying 5.25 by 1.20, and the answer would be read as 6.3. The point would then be shifted by inspection to give a reasonable answer (in this case 0.63). An experienced slide-rule operator would go a step farther and merely write the numbers without any points, as $525 \times 12 = 63$, and then point off the final answer to read 0.63.

With this in mind and remembering that the slide-rule answer may differ anywhere from $\frac{1}{10}$ to $\frac{1}{2}$ per cent from the exact answer, we may proceed to give the rules for multiplication, division and proportion, and work a few problems.

Rule 2—Multiplication: To multiply one number by a second, move the slide until an index of the slide is at the first number on the stationary scale. Then move the runner to the second number on the slide. Opposite, on the stationary scale, is the product

Problem 1: Multiply 116 by 3.75, using the *A* and *B* scales.

Solution (See Fig. 3): Bring an index (say left index) of *B* to 1.16 on *A*. Move the runner to 3.75 on *B*. Under the runner on *A* read 4.35. Write down 435. To point off, consider that the answer obtained must be in the neighborhood of that obtained by multiplying 100 by 40, which would give 4,000. So the answer should be 4,350.

Problem 2: Multiply 0.417 by 276, using the *C* and *D* scales.

Solution (See Figs. 4 and 5): Bring an index of *C* (try *left* index as in Fig. 4) to 4.17 on *D* scale. Move the runner to 2.76 on *C* scale. This runs off the *D* scale as shown in Fig. 4, so try again, bringing the *right* index of scale *C* to 4.17 on the *D* scale as shown in Fig. 5. Move the runner to 2.76 on the *C* scale. Opposite on the *D* scale read 1.150. The answer must be 115.0, since an approximate computation gives $0.5 \times 300 = 150$.

Rule 3—Division: To divide one number by a second, move the runner to the first number on the stationary scale. Then move the slide until the second number on the slide comes under the runner. Read the answer on the stationary scale opposite any index of the slide.

Problem 3: Divide 63.3 by 0.725, using the *A* and *B* scales.

Solution (Fig. 6): Bring the runner to 6.33 on *A*. Move the slide until 7.25 on *B* comes under the runner. Read 8.73 on *A* opposite index of *B*. After pointing off, the correct answer is seen to be 87.3.

Problem 4: Divide 18.36 by 297.3, using the *C* and *D* scales.

Solution (Fig. 7): Bring the runner to 1.836 on *D* scale. Move the slide until 2.973 on *C* scale comes under runner. Opposite the index on *C* scale read 6.17 on *D* scale. An approximate calculation shows the correct position of the decimal point to be 0.0617.

In reference to the last problem the objection may be raised that it is impossible to read 2.973 on the scale. Strictly speaking, this is true. There is, however, a noticeable space between 2.97 and 2.98, and it is worth while estimating three-tenths of this distance if the greatest possible accuracy is desired. This estimate is likely to be one- or two-tenths in error, but the setting will be closer than if this estimate were not made. Of course there are many problems where this degree of accuracy is not needed.

This brings up the whole question of slide-rule accuracy.

With careful operation, using a 10-in. rule, answers obtained on the upper scales should be correct to 1 part out of 500, and on the lower scales to 1 part out of 1,000. The upper scale is sometimes more convenient, particularly for problems in proportion. It is also needed for problems in squares and square root. These operations will be explained in a later article.

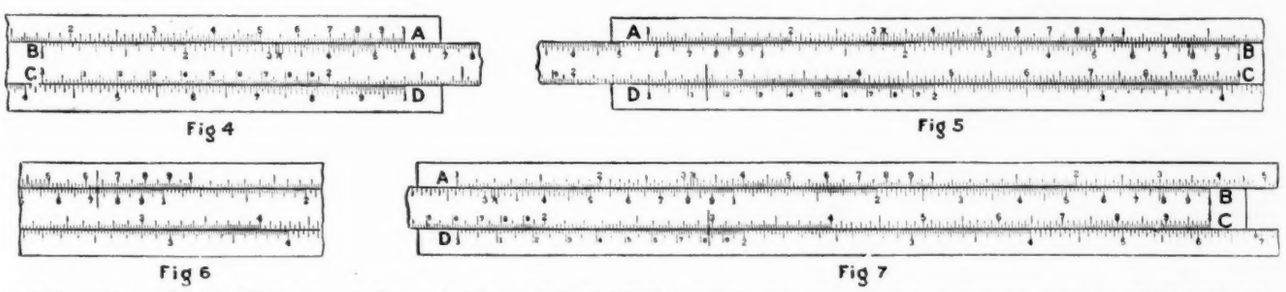


Fig 4 Fig 5 Fig 6 Fig 7

FIGS. 4 TO 7—PROBLEMS IN MULTIPLICATION AND DIVISION SHOWING USE OF BOTH UPPER AND LOWER SCALES

The possible error with a slide rule (ranging from $\frac{1}{10}$ to $\frac{1}{2}$ per cent) is not always a disadvantage in mechanical-engineering work. This degree of accuracy is entirely sufficient for about 95 per cent of the problems encountered and makes it impossible to waste time by carrying computations to a degree of accuracy not warranted by the nature of the problem. For example, in figuring the strength of a bolt nothing is gained by carrying the computation to four or five places of figures. The "accuracy" thus obtained is purely imaginary. The answer is no more reliable than the data upon which it is based. Even if the bolt were machined, making a close determination of diameter possible, there would still be a possible unknown variation of 5 or 10 per cent in the strength of the steel. In this case, then, a slide rule is far more accurate than necessary. In steam engineering there are few problems where an error of $\frac{1}{2}$ per cent is not permissible.

Sometimes, however, it is not advisable to use the slide rule. One example is in dealing with exact sums of money where a difference of a cent or two in ten dollars might not be permissible. Even in such cases the rule is very useful in making a rapid check of the long-hand computations.

A Proposed 40,000 Horsepower Motor-Ship*

By Eng. Lieut.-Commander L. J. Le Mesurier, R.N.

THE motor passenger liner of 13,000 brake horsepower now under construction at Fairfield, England, represents a notable advance in the progress of the motor-ship. Since it is a four-shaft vessel, the engines themselves are of comparatively moderate power, and all the essential problems have long since been dealt with and solved satisfactorily. It is perhaps interesting to speculate upon the maximum power per unit that may be obtained without taking either undue risks or departing from the general design of present-day single-acting two-stroke-cycle engines. As the machinery installations of all merchant vessels, with the exception of fast passenger liners, will certainly fall within this maximum, it is proposed to examine a project for a naval vessel having four shafts and developing 40,000 b.h.p. with eight-cylinder engines running at 170 r.p.m. The proposed machinery would be as follows:

	Main Engines	Auxiliary Engines
Number of engines	4	4
Number of cylinders, per engine	8	4
Diameter of cylinder, inches	33.37	18.45
Stroke of cylinder, inches	43.2	23.55
Brake horsepower per engine	10,000	1,000
Indicated horsepower per engine	12,600	1,430
Revolutions per minute	170	240
Piston speed in feet per minute	1,224	942
Indicated mean pressure, lb. per sq. in.	94.5	92

The scavenging-air turbo-blowers and the cooling-water pumps are electrically driven and absorb per main engine approximately 700 b.h.p. which is supplied by the auxiliary engines.

The total weight of the main and auxiliary engines, turbo-blowers, pumps with their motors, air reservoirs, compressors, silencers, etc., is about 2,750 tons. The weight is thus 150 lb. per brake horsepower, which compares with about 70 lb. per brake horsepower for submarines, and 290 lb. for ordinary cargo vessels fitted with Sulzer two-stroke-cycle main and auxiliary engines.

*Extract of paper read before the Institution of Engineers and Shipbuilders in Scotland, Jan. 16, 1923, at Glasgow, Scotland.

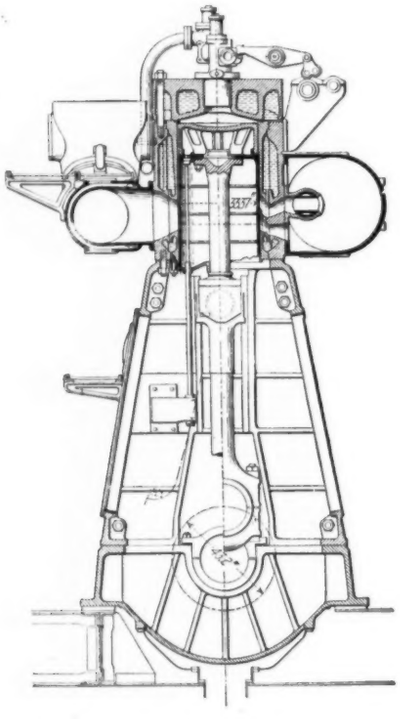


FIG. 1—PROPOSED 10,000 HORSE-POWER SULZER DIESEL

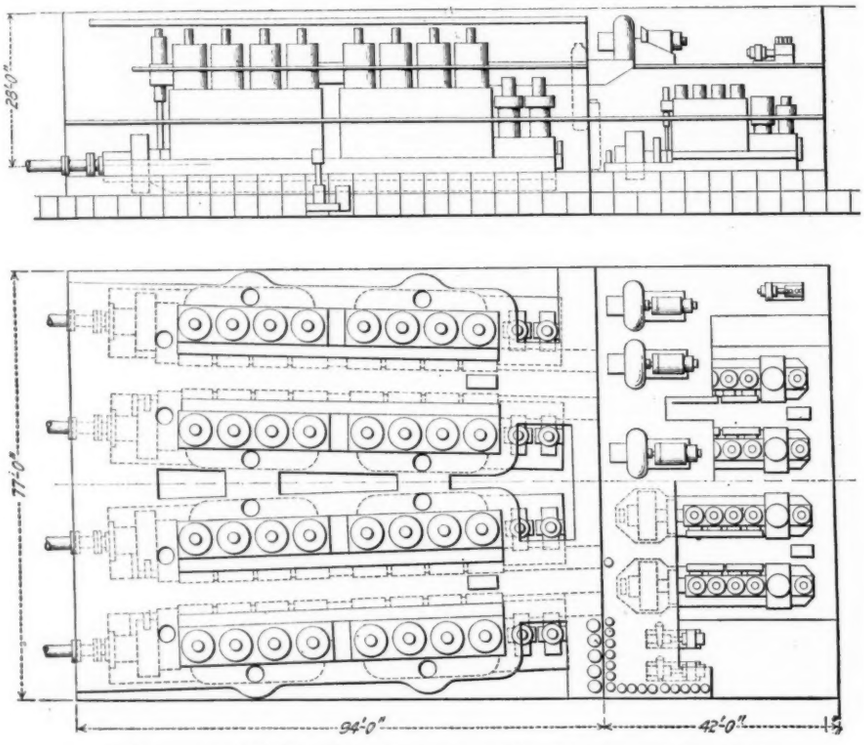


FIG. 2—ARRANGEMENT OF FOUR ENGINES ON BOARD SHIP, TOGETHER WITH NECESSARY AUXILIARY MACHINERY

In accordance with the usual practice for naval machinery, the piston speed is higher than in other types of engines, but this does not present any difficulty in regard to scavenging and charging the cylinder, while as regards the mechanical arrangements, due consideration is given to reducing the reciprocating and rotating masses by using material of greater tensile strength. In submarine engines built by the M. A. N. Co., piston speeds as high as 1,470 ft. per min. have been successfully realized in practice without excessive wear of the piston or bearings.

A very moderate indicated mean effective pressure of only 94.5 lb. per sq.in. has been chosen, which should allow for a good margin of overload. The 1,250 brake horsepower engines in the "Conde de Churruca" have worked continuously for long periods at an indicated mean pressure of about 117 lb. without any visible signs of overload, and with a clear exhaust.

Progress has been in the direction of simplifying the castings of liners, cylinder covers and pistons, and in providing large cooling-water spaces free from any obstruction. It has also been found possible, owing to improvements in design, to lessen the thickness of material in these parts, thereby reducing stresses due to the temperature difference between their inner and outer surfaces. On the whole the thermal conditions in the proposed design are more favorable than in either the experimental 2,000-hp. single-cylinder engine or the 6-Z-300 (1,800-hp. six-cylinder) engine, which has been in service for about six years.

The weight of the proposed engine per cubic foot of cylinder volume lies between the weight of a stationary engine and that of a submarine engine when measured on the same basis. The submarine engine, owing to limited headroom, requires a small stroke-bore ratio—namely, 1.05—whereas the proposed design allows a ratio of 1.3, which is more favorable, as it increases the mechanical efficiency from about 68 to 74 per cent. Taking into account the comparatively light moving masses, the total weight allows

sufficient material to be put into the bedplate, framing and cylinders to insure adequate rigidity of the whole structure.

Fig. 1 shows a section through the engine, which does not differ in any essential feature from the standard Sulzer marine Diesel. The general arrangement of four engines in a ship of 77-ft. beam, the machinery occupying a space 136 ft. long, appears in Fig. 2.

Among the advantages of the Diesel over steam machinery for naval vessels are:

1. Increased radius of action on a given fuel supply. In the proposed installation the fuel consumption would not exceed 185 tons per day.
2. The ability to proceed to sea on short notice.
3. Absence of uptakes and funnels, with consequent advantages in the disposition of armament and in less vulnerability to attack from above, owing to the reduced area of openings in the armor deck. In an aircraft carrier a perfectly free landing deck can be easily provided.
4. Risk of being put out of action by damage to steam pipes or boilers is entirely eliminated.

These advantages would appear sufficiently important to induce naval constructors to study the possibilities of high-powered Diesel engines, the employment of which in naval craft would doubtless lead to results not less far reaching than may be confidently expected from the 13,000 brake horsepower passenger liner now under construction.

Lignite Char—Its Production and Possibilities*

By O. P. Hood†

The greatest difficulty with our lignite is the fact that in nearly every district where it should be the natural fuel, it is put in competition with high-grade fuel. Canadian and North Dakota lignites must compete with anthracite and with Pittsburgh and Illinois bituminous coal; our Texas lignite must compete with gas, oil and Oklahoma bituminous coal. It is evident, however, that there must be a price at which the lower-grade fuel will begin to be attractive. In round numbers the ratio is somewhere in the neighborhood of half the price of good coal. With the rising price of bituminous coal we are fast approaching the time when this ratio will be common.

The handicaps of raw lignite are well known but not always properly valued. The heat value of high-moisture fuels, as obtained from calorimeter tests, is often misleading, because the heat carried by the moisture is recovered by the calorimeter, but cannot be fully utilized in a boiler furnace. Moreover, although the percentage of ash may be low, there is usually a larger total weight of ash to handle in a plant using lignite. The fusing temperature of the ash is usually low, making high rates of combustion difficult and requiring larger grate areas and furnace volumes than with higher-grade coal. In spite of these handicaps raw lignite now finds economic application in certain districts.

The search for a means to improve the fuel must continue. One possible improvement is to size the product more closely than is now common practice. Unlike the German "brown coal," our lignites do not make satisfactory briquets simply by drying and briquetting by heat and pressure. This is due to lack of inherent binder. Artificial binder increases the cost. An entirely satisfactory fuel can, however, be made by briquetting lignite char, and it is probable that some day such a fuel will be in common use.

With these facts in mind the United States Bureau of Mines is investigating the possibility of a program which has for its main features an inexpensive carbonizing device and the use of the lignite char, direct, without briquetting. If a market for the char can be developed and the small mines can produce it, there will be provided means for a natural evolution of an industry that, in time, may realize the larger vision of briquetting and recovery of byproducts. Lignite char can be described as a fuel rather close to anthracite in its analysis, but softer and with a little more volatile matter, so that it kindles more readily. It grades from pea coal to smaller sizes and is a stable product. This fuel burns well with natural draft, where a thin fuel bed can be maintained.

To produce the char, a simple oven has been devised that greatly reduces the investment from that needed for ovens hitherto proposed. The lignite is passed directly through a combustion zone (maintained by burning some of the distilled gases), at such a speed that the moisture and combustible gases are distilled, but very little of the fixed carbon burned away. The arrangement is something like an open-top lime kiln. The process has proved simple and efficient. Much of the gas driven off is used in the combustion zone, and in addition, less than 5 per cent of the weight of the original lignite is burned. The char obtained from such a process may of course be briquetted if desired.

An oven of this sort was operated at Grand Forks, N. D., during last summer, and about 400 tons of various North Dakota lignites passed through. In February about 100 tons of Saskatchewan lignite was tried, in order to discover whether this presented any special problems.

About 2½ tons of raw lignite reduces to one ton of char, having a heating value of about 12,000 B.t.u. per lb. The moisture is very low, and the char can be stored without danger of fire or degradation in size. Where the freight charge is heavy, it would be an advantage to ship char instead of raw lignite.

*Abstract of paper to be presented at the Spring meeting, May 28 to 31, of the American Society of Mechanical Engineers.

†Chief Mechanical Engineer, United States Bureau of Mines.

Holding on to Prosperity

At the annual meeting of the National Chamber of Commerce in New York City last week, Secretary Hoover said that we had passed the post-war crisis, recovered from an unemployment of 5,000,000 to a surplus of 500,000 jobs and become economically stronger than before the war, but that there are still some great shifts in the stream of our economic life to which we must accommodate ourselves if we would hold to full employment and prosperity.

The government index shows an increase in wholesale prices of 6 per cent in the last nine months, contrasted with a rise of 20 per cent in the nine months prior to the collapse of the 1920 boom.

"Increases in prices," Mr. Hoover says, "are a vital stimulant to production and a necessary accompaniment of business recovery," but he says also that the second safeguard of prosperity—the first being the willingness of the people to save and to resist extravagance and waste—is the business man's well developed sense of caution and resistance to the will-o'-the'wisp of higher prices and overexpansion and speculation. The third line of defense of our prosperity is our credit men and bankers, and the fourth a general comprehension and unity of action in broad phases of commercial strategy.

There is a steadily growing sense of co-operation in American business, not in restriction of trade but in a sense of collective thought and action in the broad strategy of employment, production, distribution and credits and the interdependence of the whole fabric.

We have been able to add to our standards of living by the more general distribution of articles that were luxuries ten years ago. A rough estimate shows that we could today supply each person the same amount of commodities that he consumed ten years ago and lay off two million people from work.

Examples were given of the work by the Department of Commerce in simplification of practices and elimination of waste in industry through co-operation with the industries themselves. He had recently received a statement from a single group, estimating that the savings in production cost in that trade already exceed $25,000,000 per annum.

The idea is common that hydrogen gas has an extremely high heating value. While it is true that one pound of hydrogen will release approximately 62,000 B.t.u. when burned, a cubic foot of hydrogen contains less heat than a cubic foot of ordinary city gas. The latter usually runs around 500 or 600 B.t.u. per cubic foot, while a cubic foot of hydrogen at 60 deg. F. and 30 in. barometer contains only 326 B.t.u. The cause lies in its extreme lightness.

News in the Field of Power

Gas Explosion at Atlantic City

On Monday morning, April 30, the newspapers were full of scareheads describing a disaster that took place at the Atlantic City (New Jersey) Gas Works the previous evening. According to the newspaper reports at that time, the cause of the gas explosion, which did considerable damage and caused great excitement in Atlantic City, was a "boiler explosion or steam leak" in the boiler house. Later information indicates that this statement was incorrect. The following seems to be a more trustworthy explanation:

There was a leak in the main gas line in the power house, but the operators were so accustomed to the smell of gas at all times that they did not look upon it as anything unusual. However, just after changing shifts on Sunday night, the accumulated gas caught fire from the boiler furnaces. One man was seriously injured. Being Sunday night, there were not so many employees around as usual, or the number of the injured would certainly have been much greater. It is understood that the heroism of one man probably saved a good many lives and thousands of dollars in property loss. At great risk to his life, he rushed for the main stop valve between the power house and the gas holders. If he had not succeeded in closing this valve, the disaster might have been much more serious.

How To Avoid Spontaneous Combustion

Casualties from fires caused by spontaneous combustion range annually in British ships between 50 and 100. American steamers average yearly over 60, and about 140 vessels of miscellaneous types bring the total up to 200 per year destroyed, but the portion of these attributable to coal fires has not been ascertained.

The seriousness of fires due to spontaneous combustion on ships, with the loss of life and total loss or damage to vessels, has led the Bureau of Mines to make an investigation as to causes and means of prevention. The results are given in Technical paper No. 326, by H. H. Stoek. A brief summary of the recommendation of the investigators follows:

When loading coal, trim it in horizontal layers to avoid separation of the sizes rather than dump it in a cone; clean out bunkers thoroughly before putting in fresh coal; watch for waste pieces of paper and wood during loading operations; do not put fresh coal on old coal; keep coal as cool as possible; avoid letting it come in contact with steam pipes, hot air ducts or heat of boilers and engines; take the temperature at regular intervals; if temperature goes to 100 deg. F. and is rising, move the coal to cool it off by contact with air, steam or, in extreme cases, water; provide egress for explosive gases; avoid open lights in cargo and bunker spaces; clean vents leading from bunker or cargo spaces; do not run electric wiring, unless in metal conduits, through spaces in which coal is placed. Choose coal the least friable and with low sulphur content.

Defer Action on Pulverized Fuel Regulations

At the annual meeting of the National Fire Protection Association, held at the Drake Hotel, Chicago, May 8 to 10, tentative regulations covering the installation of pulverized fuel systems were considered. These regulations were printed in "Power" March 6, 1923. It was pointed out that the regulations, as drawn, while applicable to certain industrial installations of pulverized fuel, would render it difficult for most power plants now using or installing such systems to obtain insurance. Therefore, at the request of certain users and makers of powdered-fuel equipment, the committee on Dust Explosion Hazards agreed to compile a revised code applicable to power stations and compatible with present practice; these revised regulations to be ready for the next annual meeting of the Association.

Fuel Oils and Lubricants Produced in March

According to government reports, the March production of gas and fuel oils was 970,891,272 gal., an increase of 68,000,000 gal. over February output. However, the daily average production was 31,319,073 gal., which shows a 3 per cent decrease in the daily rate of output. Stocks declined slightly to 1,254,-122,371 gallons.

Lubricants produced during March amounted to 90,745,095 gal., which shows a considerable increase (5.76 per cent) in the daily rate of production amounting to 2,927,261 gal. Stocks were 235,262,558 gal., this being a decrease of about 3,600,000 gal. There was exported during March 96,075,415 gal., or $2,856,843 worth of gas and fuel oils, and 29,895,955 gal., or $6,695,069 worth of lubricating oils.

Alabama Power Co. Project

The first unit, consisting of 24,000 hp. of the Coosa River project of the Alabama Power Co., was put into operation April 7, at Mitchell Dam. The load on the company's system is growing so rapidly that the immediate installation of two additional units is proposed. The complete development of five units will have a capacity of 120,-000 hp.

The need for power is so great in the South that the company has contracted for the use of the Warrior reserve steam plant of 45,000 hp. and the Sheffield plant of 60,000 hp., which are owned by the government and were built during the war for use in connection with the nitrate plants at Muscle Shoals. Other hydro-electric developments on the Tallapoosa and Coosa Rivers are also proposed by the Alabama Power Co., which has on file with the Federal Power Commission applications aggregating 285,000 hp.

The Alabama Power Co. has also filed a petition with the Federal Power Commission of Alabama asking for a license looking to the development of the power at the government's navigation dam, known as Lock 17, on the Warrior River, about twenty miles north of Tuscaloosa, Ala., according to the announcement of Thomas W. Martin, president of the company. The dam at Lock 17 is 63 ft. high and 1,200 ft. long. It is proposed to tie in the Lock 17 plant with the six other hydro-electric steam-generating stations. This power is badly needed by the Alabama Power Co. as a voltage boost for the Tuscaloosa District, which is at the end of its single circuit line. The dam was completed by the government in 1915, and since that time the power at Lock 17 has been going to waste.

Sleeping on Rights Abroad Jeopardizes Capital

There are a large number of patents and processes invented, owned and profitably worked by Americans in the United States, which, while patented abroad, have never been marketed there. The compulsory working clause of the British patent law places every unworked American invention in jeopardy.

In Great Britain there are many industrial establishments that were greatly overbuilt during the war, whose owners are desirous of making something for the British market and would gladly take over the making and selling of well-established American products owned by responsible concerns.

To facilitate the carrying out of such an arrangement, William Whittam,

formerly special agent in England of the U. S. Dept. of Commerce, has organized the firm of Middleton-Whittam Inc., with offices at 565 Fifth Ave., New York City.

To Develop 105,000 Hp. at Oak Grove

As plans of the Portland (Ore.) Railway Light & Power Co. develop for the construction of its Oak Grove hydroelectric project, it is foreseen that the ultimate power available will be 105,000 hp. instead of 100,000 hp., as originally figured. The total cost of the development will be $12,000,000, or $2,000,000 more than contemplated. With the approach of summer construction work is progressing rapidly on the first unit, which will develop 25,000 hp. Work is being rushed on a 25-mile extension of railroad in order that material can be transported to the dam and powerhouse sites. A force of 1,800 men is now engaged on the various phases of the work. It is expected that the first unit will be completed and in operation early in 1924.

Recent Legislation for Engineers in New York

The Ferris bill, extending from May 5 to Aug. 1, 1923, the time under which engineers must have a license under the provisions of Art. 4a of the general business law, passed both houses of the New York State Legislature and was signed by the Governor on May 5 as chapter 330 of the Laws of 1923.

The Kavanaugh bill (Senate Print No. 2237) exempting from the provisions of Art. 4a of the general business law, professional engineers or land surveyors, engaged solely as officers or employees of corporations engaged in interstate commerce, passed both houses of the legislature and is in the hands of the Governor as a thirty-day bill.

Water Power Amendment Goes to N. Y. Voters This Fall

The Ferris concurrent amendment to the Constitution, permitting the use of 3 per cent of the lands and waters of the forest preserve for the building of transmission lines and power stations in connection with the development of state water power, passed the legislature of 1922, it now goes to the Secretary of State to be submitted to the voters for ratification at the general election in November.

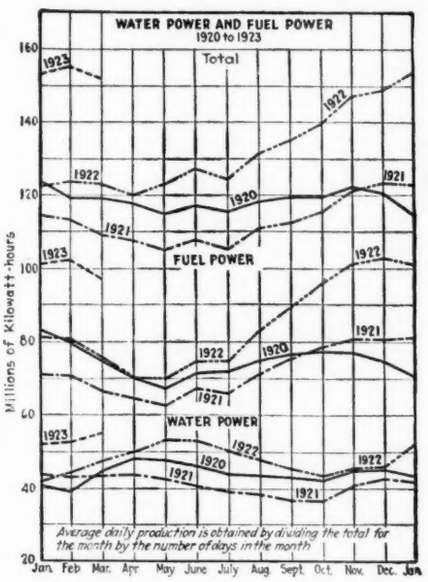
The drouth during the past season has made it clear to the new hydroelectric companies in Japan that they must install steam auxiliaries. It is expected that the Japanese will be in the market extensively for steam-plant equipment. The demand for power also is increasing to the point where there is a much greater demand for carrying loads through the year. The Japanese rivers are short and the opportunities for storage are few

Production of Electricity Decreases 1.6 per Cent

The average daily production of electricity by public-utility power plants during the month of March was 152,000,000 kw.-hr., or 1.6 per cent less than the average daily output in February. The revised figure for the daily output in February is 154,400,000 kw.-hr., which now stands as the record rate of daily production of electricity by public-utility plants in the United States.

The slight decrease in the rate of production in March was probably due to the usual seasonal decrease in demand for electricity. It is not anticipated, however. that the seasonal decrease this year will be at all marked.

The average daily production of electricity for the first three months of 1923 and the proportion produced by water power were as follows: January,



MARCH POWER CURVE DESCENDS

153,300,000 kw.-hr.—34 per cent; February, 154,400,000 kw.-hr.—33.9 per cent; and March, 152,000,000 kw.-hr.—36 per cent. The increase in the amount of water available for the use of hydro-electric power plants is reflected in the increase in the proportion of the total amount of electricity produced by the use of water power.

The quantities in the tables are based on returns received from about 3,500 power plants each producing 10,000 kw.-hr. or more per month engaged in public service, including central stations, electric railways and certain other plants that contribute to the public supply. The capacity of plants submitting reports of their operations is about 95 per cent of the capacity of all plants listed.

There were 1,697,361,000 kw.-hr. of electricity produced by water power and 3,013,248,000 kw.-hr. by fuels. There were 3,349,978 short tons of coal, 1,190,495 bbl. of fuel oil and 2,271,980,000 cu.ft. of natural gas consumed by public-utility power plants during March.

Obituary

John Gilbert Ward, for thirty years treasurer of the Babcock & Wilcox Co., died at his residence, Glen Ridge, N. J., Sunday, April 22. He was born July 12, 1854, in Cuba, where his father, who was an Englishman, had settled for a time. His mother was Cuban. He came to the United States with his parents early in life, and his boyhood was spent in the State of Delaware; later, the family moved to New Jersey.

Mr. Ward spent the greater part of his life in the service of the Babcock & Wilcox Co., with which he became connected in 1888 as a clerk in the treasurer's office. A little later he became assistant to the treasurer, Nat W. Pratt, and in 1893, he was elected treasurer and a director of the company, both of which positions he held continuously until the time of his death. He was universally popular among his associates and subordinates, of whom he was the dean in point of service.

Personal Mention

E. S. Fitz, who has been electrical engineer and general superintendent of the Houghton County Electric Light Co., Houghton, Mich., has entered the power station betterment division of Stone & Webster, Inc., Boston, Mass.

H. F. Eastman, formerly assistant superintendent in charge of gas and electric plants for the Connecticut Power Co., of New London, Connecticut, is now an engineer in the mechanical division of Stone & Webster, Inc., Boston, Mass.

Herbert L. Fisher is now doing appraisal work with Stone & Webster, Inc., Boston, Mass. Mr. Fisher was formerly resident engineer with the Goodyear Tire and Rubber Co. and later with the St. Croix Paper Co. as assistant engineer of hydraulic construction, and later with the J. McCormick Construction Co.

Society Affairs

The **Baltimore Section** of the **A. S. M. E.** will take a joint trip with the **A. C. S.** to the Davidson Chemical Co.

The **Atlanta, Ga., Branch** of the **A.S.M.E.** on May 22 will hear P. S. Arkwright speak on "Hydro-Electric Rates."

The **New Haven Branch** of the **A. S. M. E.** on May 21, will hear Professor L. P. Breckenridge speak on the "Past and Future of Engineering."

The **Detroit Section** of the **A.S.M.E.** and the **University of Michigan** will hold a joint meeting at Ann Arbor on May 19. Elmer A. Sperry will speak on the Gyroscope.

The **F. A. E. S.** announce the appointment of four of the members of the committee to conduct an investigation of the storage of coal. They are: P. F. Walker, Dean of Engineering of University of Kansas; S. W. Parr, Professor of Applied Chemistry, University of Illinois; H. Foster Bain, Director of the U. S. Bureau of Mines; L. E. Young, Union Light and Power Co., St. Louis. The chairman, W. L. Abbott, is chief operating engineer of the Commonwealth Edison Co., Chicago.

The **National Electric Light Association,** 29 West 39th St., New York City, announce that it is absolutely necessary for the electric light and power men to send in their advance registration and hotel accommodation applications to N. E. L. A. headquarters at the earliest possible moment, in order that adequate plans may be made for their comfort. Only through advance registration can the Convention Committee determine the amount of accommodation needed, and the number of sets of advance convention papers to be printed. It is their desire to avoid confusion and the disappointment of delegates so far as possible. With co-operation from those who expect to attend, all possibility of this can be obviated.

Business Notes

The Niagara Falls Power Co., Buffalo Branch has changed its address to 1525 Marine Trust Bldg., Buffalo, N. Y.

The **Pure Carbon Co.,** Wellsville, N. Y., announces the establishment of a Minneapolis representative, the Chas. A. Etem Co., 917-A Marquette Ave., Minneapolis, Minn.

C. J. Tagliabue Manufacturing Co. is putting upon the market an easier reading thermometer with a new feature known as the Tag-Hespe Red Reading Column. It shows a broad red line from the top of the mercury column to the top of the tube, which attracts the eye. It is then easy to read down to the mercury.

The Erie Ball Engine Co., of Pittsburgh, Pa., has changed the address of its New York City office from 132 Nassau St., to Room 5050 Grand Central Terminal Bldg., 70 East 45th St.

The Westinghouse Electric & Manufacturing Co. announces the following changes in personnel: Graeme Ross has been appointed manager of the Kansas City Branch; E. L. Doty, formerly service manager at Buffalo, is to be engineering assistant, service department, East Pittsburgh; J. A. Atkinson is to be service manager at Buffalo; C. W. Jones to be general foreman of the controller department at East Pittsburgh; C. A. Fike has been appointed general foreman of the coils and insulation department, East Pittsburgh; J. H. Hartman is to be general foreman of the storekeeping department, East Pittsburgh; W. S. Oswald to be general foreman of the railway motor department at East Pittsburgh.

Coming Meetings

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Thirty-fifth Annual Convention at Hot Springs, Va., June 4-6.

American Order of Steam Engineers; W. J. Brice, 2126 S. 57th St., Philadelphia, Pa. 37th Annual Convention at Reading, Pa. (instead of Philadelphia, as formerly announced), June 4-8.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Penn. Annual meeting at Atlantic City, N. J., June 25-30.

American Society of Heating & Ventilating Engineers; O. W. Obert, 29 West 39th St., New York City. Semi-annual meeting, Chicago, May 21-23.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Spring meeting at Montreal, Canada, May 28-31.

American Water Works Association, 163 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th Annual Convention at Toronto, Canada, June 25-28.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

International Railway Fuel Association; J. G. Crawford, 702 East 51st St., Chicago. Annual meeting at Cleveland, Ohio, May 21-24.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Indiana,** at La Fayette, Ind., May 28-29; T. J. Kelly, 2704 South St., La Fayette, Ind. **New Jersey,** at Trenton, N. J., June 1-3; Samuel Clark, 67 Columbia St., Jersey City, N. J. **Illinois,** at Springfield, Ill., June 6-9; F. W. Raven, 417 South Dearborn St., Chicago. **New England States Association,** at Manchester, N. H., July 12-14; Freeman L. Tyler 32 Briggs St., Taunton, Mass. **Iowa,** at Mason City, Iowa, June 11-14; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa. **Ohio,** at Dayton, June 21-23; J. H. Weaver, 22 N. Gift St., Columbus, Ohio. **Pennsylvania,** at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York,** at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota,** at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Ave. N. E., Minneapolis. **Connecticut,** at Waterbury, June 29-30; L. Van Der Eyk, 251 Wood St., Waterbury.

National District Heating Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Smoke Prevention Association; Frank Chambers, 111 N. Dearborn St., Chicago, Ill. Convention at Minneapolis, Minn., June 19-22.

Society for the Promotion of Engineering Education; F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. Annual meeting at Cornell University, Ithaca, N. Y., June 20-23.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Rochester, N. Y., Aug. 7-11.

Trade Catalogs

Boilers, Uniflow Improved Return Tubular—Lebanon Boiler Works, Harrison Bldg., Philadelphia, Pa. Bulletin 23-A describes and illustrates the uniflow boilers.

Boilers—Oswego, Internally Fired Water Tube, A. D. Granger Co., New York City. Bulletin No. 2 covers both type "A" boiler, a standard, and type "B" with down-draft Hawley-type grates.

Welded Joints—Oxweld Acetylene Co., Newark, N. J. Pamphlet—How welded joints solved pipe-line troubles. Reprints of papers by N. E. Wagner, E. E. Lungren, G. O. Carter, and an interview with Harry A. Callon.

Wood Pipe—The Continental Pipe Manufacturing Co., Seattle, Wash., has issued catalog No. 18, describing Continental wire-wound wood pipe, Continental continuous-stave wood pipe and Continental creo-wood flume. The book contains many illustrations and tables and engineering data.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Apr. 23, 1923	May. 7, 1923
Pool 1,	New York	$3.50–4.25	$3.50–4.00
Smokeless,	Columbus	4.00–4.50	3.75–4.25
Clearfield,	Boston	2.25–3.25	2.00–3.00
Somerset,	Boston	2.00–2.50	2.25–3.25
Kanawha,	Columbus	2.00–2.50	2.00–2.50
Hocking,	Columbus	1.85–2.20	1.85–2.10
Pittsburgh No. 8	Cleveland	2.10–2.25	2.10–2.25
Franklin, Ill.,	Chicago	3.00–3.25	3.00–3.25
Central, Ill.,	Chicago	2.00–2.25	2.00–2.25
Ind. 4th Vein,	Chicago	2.75–3.00	2.75–3.00
West Ky.,	Louisville	2.00–2.25	1.85–2.00
S. E. Ky.,	Louisville	2.50–2.75	2.15–2.75
Big Seam,	Birmingham	2.00–2.25	1.85–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—May 10, Port Arthur light oil, 22@25 deg. Baumé, 5⅝c. per gal.; 30@35 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—May 5, 24@26 deg. Baumé, $2.12 per bbl.; 32@36 deg., $2.33 per bbl. tank cars.

Philadelphia—May 6, 26@28 deg. Baumé, Oklahoma, $1.10@$1.20 per bbl.; 30@34 deg., Oklahoma (group 3), 3@3⅛c. per gal.; 16@20 deg. Seaboard, $1.60@$1.75 per bbl.

St. Louis—May 1, tank-car lots, f.o b. St. Louis; 24@26 deg., $1.90 per bbl., 26@28 deg., $1.95 per bbl.; 28@30 deg., $2.00 per bbl.; 32@36 deg., gas oil, $2.20 per bbl.; 36@40 deg., distillate $2.30 per bbl.

Pittsburgh—April 30, f.o.b. local refinery, 30@34 deg., fuel oil, 5⅜c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.; 34 deg., neutral, 9¼c. per gal.

Dallas—May 5, f.o.b. local refinery, 26@30 deg., $1.58 per bbl.

New Plant Construction

PROPOSED WORK

Ala., Birmingham—The Southern Ry. Co., American Trust Bldg., plans the construction of a 10 story, 50 x 100 ft. office building on I Ave. and 22nd St. N. Estimated cost $750,000. Engineer and Architect not announced.

Ala., Talladega—H. H. Thornton, City Comr., will receive bids until June 4, for the construction of a water supply system consisting of a 10 ft. concrete intake dam, 16 in. c. i. intake, pumping station, 2,000,000 gal. service reservoir, coagulating basin, three 500,000 gal. concrete filters, 200,000 gal. clear water reservoir and approximately 19,000 ft. 16 in. c. i. supply main. P. H. Norcross, 1404 Candler Bldg., Atlanta, Ga., Consult. Engr.

Calif., Chico—J. B. Thompson, engr., has prepared preliminary plans for irrigation district to be organized to irrigate approximately 15,000 acres in Butte Co., Project includes 20.8 mi. canals, two 24 in. and two 12 in. centrifugal pumps, both to be operated by 200 hp. electric motors. Cost will exceed $1,000,000.

Calif., Eureka—The Eureka Ice & Cold Storage Co. plans the construction of an ice and cold storage plant. Cost to exceed $100,000.

Calif., Long Beach—C. J. Harper c/o Sea Gull Apartments, is having plans prepared for the construction of a 10 story, club, hotel and store building, on Ocean Blvd. and Locust St. Cost will exceed $500,000. H. L. Gogerty, 239 East Broadway, Archt. Equipment detail not reported.

Calif., Long Beach—J. C. Lindsey and W. Horne Co., Agents, 38 American Ave. Bldg., are having plans prepared for a 13 story, 80 x 120 ft. office building, on 3rd St. Estimated cost $900,000. Walker & Eisen, Pacific Finance Bldg., Los Angeles, Engrs. Noted Apr. 24.

Calif., Oakland—The Oakland Hospital Assn., c/o M. I. Diggs, Archt., 1901 Telegraph Ave., is having plans prepared for the construction of an 8 story, 131 x 175 ft. hospital on 31 and North West Telegraph Sts. Estimated cost $750,000. Equipment detail not reported.

Calif., Sacramento—The Sisters Hospital, c/o R. A. Herold, Archt., Forum Bldg., received bids for the construction of a 5 story hospital on 40th and J Sts. Separate bids will be received for mechanical equipment, heating, ventilating, etc. Noted Mar. 20.

Calif., San Francisco—The St. Francis Hotel Co., Powell and Geary Sts., is having plans prepared for the construction of a 5 story hotel annex on Post and Powell Sts. Estimated cost $1,000,000. Bliss & Faville, Balboa Bldg., Archt. Equipment detail not reported.

Calif., San Francisco — The Women's Building Assn., c/o Bliss & Faville, Archt., Balboa Bldg., is having plans prepared for the construction of a 9 story club and hotel building on Mason and Sutter Sts. Estimated cost $750,000 to $1,000,000. Equipment detail not reported.

Calif., South San Francisco (San Francisco P. O.)—The Metal & Thermit Corp., E. W. Kardos, Dist. Mgr., c/o Swift & Co., is receiving bids for the construction of rolling mill buildings on Swift Ave. Estimated cost $2,000,000. Eng. Dept. of Owners, 1429 Western Ave., Pittsburgh, Pa., Engrs. Equipment detail not reported.

Calif., San Pedro—The Army and Navy Young Men's Christian Association, plans the construction of a club building here. Cost will exceed $500,000.

Conn., Meriden—The Commercial School for Boys, E. S. Boyd, Supt., is in the market for 2 boilers. Estimated cost $31,000.

Fla., St. Petersburg—E. M. Elliot & Associates are having plans prepared for the construction of an 800 room hotel including refrigeration, light and heating plants on 5th Ave. N. and Beach Drive. Estimated cost $2,000,000. G. Lloyd Preacher, Healy Bldg., Atlanta, Ga., Archt.

Ga., Yatesville—The Yatesville Planing Mill Co. is in the market for engine, boiler and power house equipment.

Ill., Chicago—The Abbott Investment Co., 179 West Washington St., is having plans prepared for the construction of a 13 story, 62 x 132 ft. hotel and stores building, including a steam heating system, at 1533 North Dearborn St. Estimated cost $1,000,000. C. E. Frazier, 30 North Dearborn St., Archt.

Ill., Chicago—H. Mack, c/o Lexington Hotel, 2135 Michigan St., is having plans prepared for the construction of a 7 story, 90 x 136 ft. hotel, including steam heating system on North Clark and North Park Aves. Estimated cost $1,500,000. W. W. Ahlschlager, 65 East Huron St., Archt.

Ill., Chicago—Olsen & Urbain, 155 North Clark St., is receiving bids for the construction of a 3 story, 100 x 150 ft. apartment hotel at 525 Arlington Pl. for owner, c/o F. D. Mateer, 420 Fullerton Ave. Estimated cost $750,000. Equipment detail not reported.

Ia., Dubuque—The city, O. E. Carr, Mgr., will receive bids until May 24, for the construction of a waterworks pumping station, centrifugal pump, 2 air compressors, 5 air lift well pumps and 1 well. Estimated cost $200,000. Mead & Seaston, Journal Bldg., Madison, Wis., Engrs. Noted April 3.

Ia., Elkader—The Peoples Electric Service Co., c/o P. H. Schmith, plans the construction of a dam in Turkey River and hydro-electric power plant.

Kans., Chanute—The city, C. G. Wood, Clk., will receive bids until May 18, for furnishing and installing in the municipal light plant, the following equipment: one 1,000 kw. (80 P F) or 1,250 kva. turbo alternator, 2,300 volt, 3 phase, 60 cycle; one 30 K W D C exciter set, steam turbine driven; one surface condenser for above turbines, with necessary auxiliaries; one 10 ton traveling crane, hand operated. Black & Veatch, Mutual Bldg., Kansas City, Mo., Consult. Engrs.

Ky., Louisville—The Citizens Hotel Co., W. K. Stewart, Chmn., is having plans prepared and will soon receive bids for the construction of an 18 story, 124 x 150 ft. hotel on 5th and Walnut Sts. Estimated cost $2,300,000. B. B. Davis, Norton Bldg., Archt. Equipment detail not reported. Noted April 3.

La., New Orleans—The U. S. Engineers Office, 329 Custom House, will receive bids until May 25, for the construction and delivery of one 15 in. dredge pump.

Md., Easton—The Mayor and city council will receive bids until May 31, for the construction of certain extensions to the sewerage system, consisting of about 1 mile 8 to 12 in. sewer, small pumping station and 4 in. force mains, etc. E. G. Kastenhuber, Engr.

Mich., Detroit — The Bd. Educ., 1354 Broadway, is having plans prepared for the construction of 13 two story school buildings, including steam heating plants with plenum system and mechanical ventilators. Estimated cost $4,382,217. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archts.

Mich., Detroit — J. A. Martin - Cooke, Archt., 17732 Woodward Ave., is receiving bids for the construction of an 8 story, 165 x 165 ft. apartment building, including steam heating system, elevators, etc., on Chene St. and Grand Blvd.

Mich., Iron Mountain — The Michigan Iron, Land & Lumber Co., is having plans prepared for hydro-electric power plant, 450 ft. dam, 30 ft. head, 10 large steel flood gates, etc. Estimated cost $1,000,000. Mead & Seastone, Journal Bldg., Madison, engrs. Noted Apr. 10.

Mich., Pontiac—The Oakland Body Corp., Baldwin Ave., will soon award the contract for the construction of a 85 x 113 ft. power house and reservoirs with two 70 x 70 ft. tanks. A. Kahn, 1000 Marquette Bldg., Detroit, Archt. Heating and ventilating equipment, 4 boilers, stokers, etc., coal and ash handling equipment, conveyors and elevators will be required.

Minn., Minneapolis — The Minneapolis General Electric Co., R. P. Pack, Gen. Mgr., 15 South 15th St., is having plans prepared for the construction of a terminal station on 1st and Aldrich Aves. N. Estimated cost $75,000. Owner's Engineering Dept., Engrs.

Minn., Minneapolis—The State Bd. of Control, D. F. Mullen, Secy., Capitol, St. Paul, will receive bids until May 18, for the construction of a 3 story, electrical engineering building, including electrical equipment for instructional purposes, at the State University, here. Estimated cost $300,000. C. H. Johnson, 715 Capital Bank Bldg., St. Paul, Archt. C. L. Pillsbury Co., 1200 Second Ave. S., Minneapolis, Engrs. Noted Jan. 31, 1922.

Mo., Kansas City—The Heart of America Hospital Assn. plans the construction of a hospital on 31st and Tracy Sts. Estimated cost $1,000,000. Engineer or architect not selected.

N. J., Kearney — The Western Electric Co., 195 Bway., New York, will soon receive bids for the construction of a cable building here. McKenzie, Voorheis & Gmelin, 347 Madison Ave., New York, Archt. O. C. Spurling, 195 Bway., New York, Engr. Also having plans prepared for a power plant here. J. G. White, 43 Exchange Pl., New York, Engr.

N. Y., Brooklyn—The Wheeler Electric Co., 711 Carroll St., is in the market for a 30 hp. 3 phase, motor.

N. Y., Fisher's Island — The Quartermaster, U. S. Army, Fort G. W. Wright, will receive bids until May 28, for one set 50 kw. synchronous motor generator.

N. Y., New York—C. Cromwell, 596 Bway., is in the market for a gear driven, air compressor.

N. Y., Rochester—Staub & Son, Inc., 951 Main St., is in the market for complete boiler house equipment for large boiler house now under construction.

N. Y., Watertown—J. W. Ackerman, City Mgr., will receive bids until May 25, for the construction of a hydraulic electric plant, including a 40 x 115 ft. power house and a diversion dam. P. B. Sutton, City Engr.

N. C., Asheville—The G. Vanderbilt and Battery Park Hotel Cos., awarded the contract for the construction of a hotel to the W. M. Sutherland Bldg. & Contg. Co., Compton Bldg., St. Louis, Mo. Estimated cost $1,500,000. Equipment detail not reported. Noted May 1.

N. C., Durham — Company recently organized plans the construction of a 10 story hotel on Market St. Estimated cost $1,000,000. Address R. W. Rigsbee, City Mgr.

N. C., Tryon—The Blue Ridge Power Co., Hendersonville, plans the construction of a power plant here. Estimated cost $875,000.

N. D., Bismarck—The city, M. H. Atkinson, Clk., will receive bids until May 28, for the construction of waterworks, including distribution system, pumping station and equipment, reservoirs, filtration and softening plants. Estimated cost $704,000. T. R. Atkinson, City Engr. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Minn., Consult. Engr.

Ohio, Canton—The Schory & Shellhase Ice Co., 6th St. & Harrison Ave. S. W., plans construction of an addition to ice plant, to increase the capacity 130 tons. Estimated cost $50,000. Ice making machinery cost about $150,000 will be installed.

Ohio, Cleveland—The city will receive bids until May 18, for furnishing 1976 electric meters for city light plant.

Ohio, Cleveland—The Cleveland Electric Illuminating Co., E. G. Crawford, Secy., Illuminating Bldg., is receiving bids for the superstructure of substation at the foot of East 70th St. Estimated cost $750,000. E. G. Cook, Illuminating Bldg., Archt. J. C. Spencer, Engineers Bldg., Engr. Equipment detail not reported. Noted Mar. 6.

Ohio, Cleveland—The Cleveland Laundry Co., H. P. Shupe, 2840 Carnegie Ave., is in the market for one 300 hp. boiler and stokers.

Ohio, Painesville—The city, T. B. Wyman, Mgr., is in the market for one 475 hp. vertical tube boiler, radial brick stack and concrete spray pond.

Ohio, Sandusky—The Bd. of County Comns. is having preliminary surveys made for water lines, pumping station and sewerage disposal plant for Castalia section in Erie County. R. E. Garvin, Davis & Farley Bldg., Cleveland, Engr.

Okla., Antlers—The City is having plans prepared for the construction of a rapid sand filtration plant, including pipe line extensions and motor driven triplex pumps. Estimated cost $30,000. H. G. Olenstead & Co., Oklahoma Bldg., Oklahoma City, Engr.

Okla., Antlers—The Oklahoma Power Co., C. H. Kretz, Pres., Okmulgee, plans to build a hydro electric power plant on the Kiamichi River, here. Estimated cost $500,000. Engineer not selected.

Okla., Cushing—The city plans election the latter part of the month to vote on bonds for new waterworks including filtration plant, pumps, extension to mains and concrete reservoir. Estimated cost $500,000. Benham Eng. Co., 512 Gumbel Bldg., Kansas City, Mo., engrs.

Pa., Clearfield—The Clearfield Hospital is having plans prepared for the construction of a 2 story hospital addition. Estimated cost $250,000. Howard & Hatcher, Deposit National Bldg., Dubois, Archt. Equipment detail not reported.

Pa., Rixford—A. L. Lilly is in the market for a 10 hp. gas engine.

Pa., Scranton — M. E. Comerford, c/o Comerford Amusement Corp., 303 Lackawanna Ave., plans the construction of a theatre building on Wyoming Ave. Estimated cost $500,000.

Tenn., Knoxville—The Duncan Machinery Co., Box 265, is in the market for 100 hp. Scotch marine type or economic boiler with 80 to 100 hp. engine, prefer Leffel boiler; 100 hp. 100 lbs. working pressure, Scotch marine boiler with fixtures complete; 100 hp. A.C. 3 phase, 60 cycle, 220 volt motor (new or used).

Tenn., Madisonville—The city will receive bids about June 1, for the construction of a waterworks system, including electrically power driven machinery, storage tank, etc. Estimated cost $35,000. Ambler Eng. Co., Old Dominion Trust Bldg., Richmond, Va., Engrs.

Tex., Dallas—The North Texas Conference M. E. Church South, J. H. Groseclose, Supt., 807 Mercantile Bank Bldg., is having plans prepared and will soon receive bids for the construction of the first unit of sanitarium, including steam heating system, on Ballard and Grover Sts. Estimated $400,000. Total estimated cost $1,500,000. De Witt & Lemmon, 507 S. W. Life Bldg., Archts.

Tex., San Antonio — R. H. Cameron, Archt., 1115 Natl. Bank Bldg., is preparing plans and will receive bids about July 1, for the construction of a 12 story, 90 x 100 ft. medical arts building, including heating, ventilating equipment and three electric elevators, on East Houston and Losoya Sts. Estimated cost $650,000. W. E. Simpson Co., North Bank Commerce Bldg., Engr. Owner's name withheld.

Tex., San Antonio—The city will receive bids about June 15, for the construction of a 2 story, 110 x 140 ft. municipal auditorium on Romana Sq. Estimated cost $500,000. R. H. Cameron, 1115 City Natl. Bank Bldg., Archt. The W. E. Simpson Co., Natl. Bank Commerce Bldg., Engrs. Equipment detail not reported. Noted Feb. 7, 1922.

Va., Gloucester — The Gloucester Ice & Refrigerating Co., A. Crosby, Pres., is in the market for ice manufacturing machinery and equipment.

Wash., Olympia—The Superior Portland Cement Co., Seaboard Bldg., Seattle, has filed application with the State Supervisor of hydraulics, for water appropriation for large hydro-electric power project on Jackman Creek, King Co., including power plant, 2.37 mi. pipe line, diversion dam 10 ft. high and 50 ft. long, static head 680 ft., total development 4,250 hp.

Wis., Milwaukee—Milwaukee Elks Lodge, 448 Jefferson St., rejected bids opened April 16, for the construction of the superstructure of a 9 story, 110 x 145 ft. club house on Juneau Pl. Estimated cost $1,000,000. Plans will be revised and work readvertised. R. Messmer & Bro., 221 Grand Ave., archts. Noted March 13.

Wis., Sheboygan—Ferris Skaff, 928 Wisconsin St., is in the market for ice machine and refrigeration equipment, etc., for store building at Fond du Lac.

Wis., Sheboygan—The Sheboygan Gymnastic Assn., c/o E. A. Juul, Engr., 211 Security Bldg., is having plans prepared for furnishing and installing steam heating plant and boilers. Estimated cost $25,000.

Ont., Eastview — The town, J. Wolfe, Engr., Cummings Bridge, Ottawa, is in the market for pumps, motors, etc., for waterworks.

Ont., Elk Lake—The Matachewan Canadian Gold Mines, King Edward Hotel Bldg., Toronto, plans the construction of a gold mining mill. Owner is in the market for equipment, including electric motors.

Ont., Huntsville — The Muskoka Wood Mfg. Co., R. J. Hutcheson, Mgr., plans the construction of 40 x 40 ft. boiler house, 2 or 3 boilers will be required.

Ont., Kitchener—The city, S. Shupe, Engr., City Hall., is having plans prepared for the construction of an activated sludge plant with gravity system and booster pump and station. Estimated cost $85,000.

Ont., Kitchenor — Watt & Blackwell, Archts., Bank of Toronto, London, will receive bids until about June 7, for the construction of a 3 story, 150 x 185 ft. hospital on King St. for the Sisters of St. Joseph, Hamilton. Estimated cost $450,000. Owner is in the market for all materials and complete equipment for modern hospital.

Ont., Toronto—The Ravina Ice Arena, Jennings St. and Rowland Ave., plans to replace their present rink with a new artificial arena, including steam heating system and artificial ice machinery. Engineer or architect not selected.

Ont., Windsor—Essex Co. Electric Comn. E. S. Frost, Ch. Engr., c/o Hydro-electric Power Comn. of Ontario, Administration Bldg., 190 University Ave., Toronto, plans to replace small transformers and feed wires in several districts. Estimated cost $40,000. Prices wanted.

Quebec — The Northern Canada Power Co., Timmins, Ont., has secured power lease on Des Quinze River at Ka-Ka-Ke Rapids, for power development to include concrete dam and power house, turbines, generators, transformers, oil and water pumps, switches, transmission lines, etc. Initial development 20,000 hp. ultimate development 100,000 hp. Estimated cost $3,000,000-$4,000,000. Viele, Blackwell & Buck, 49 Wall St., New York City, engrs.

Que., Acton Vale—The town, A. Beaudoin, Secy., will receive bids until May 21, for complete equipment for pumping station, including mechanical gravity filters, steel tower of 100,000 gal. capacity and 2,450 ft. pipe.

Que., Bagotville—The town is in the market for complete equipment for electric light and power plant.

Que., Iberville—The town, O. Beaudoin, Engr., 71A St. James St., Montreal, is in the market for equipment, including centrifugal pumps, motors and gasoline engine.

CONTRACTS AWARDED

Ala., Florence—The U. S. Engineers Office, awarded the contract for furnishing and installing steam boilers, etc., on the United States towboat, General John Coffee, to C. Hegewald, New Albany, Ind., $17,890. Noted Apr. 10.

Calif., Sacramento—E. Troop and W. C. Crittenden, 129 Sutter St., San Francisco, awarded the contract for the construction of a 3 story department store on K St. to Cahill Bros., 110 Sutter St., San Francisco. Estimated cost $700,000. Equipment detail not reported.

Calif., San Francisco—The Medico-Dental Bldg. Corp., c/o G. W. Kelham, Archt., Sharon Bldg., awarded the contract for the construction of a 12 or 15 story, physicians' and dentists' building, on Post and Mason Sts., to G. Wagner, 251 Kearny St. Estimated cost $1,350,000. Noted April 3.

Ill., Chicago—The Abbott Investment Co., 179 West Washington St., awarded the contract for the construction of a 13 story, 49 x 149 ft. club house at 1244 North Dearborn St. to The Fitzgerald Construction Co., 105 West Monroe St. Estimated cost $1,500,000. Steam heating system will be installed.

Ill., Chicago—A. Johnson, 331 Diversey Pkway., awarded the contract for the construction of a 12 story, 100 x 150 ft. hotel at 2751 Pine Grove St., to J. A. Lundstrom, 1401 Balmorel Ave. Estimated cost $1,500,000. Steam heating system will be installed. Noted Feb. 6.

Ill., Chicago—V. C. Williams, 3257 Warren St., will build a 3 story, 125 x 170 ft. hotel building., by day labor, at 3250 Park Ave. Estimated cost $500,000. Steam heating system will be installed.

Ill., Evanston—W. H. Bell, c/o H. A. Mulder, Archt., 140 South Dearborn St., Chicago, awarded the contract for the construction of two 3 story, 150 x 175 ft. apartment buildings on Ridge and Hall Sts., to Whyte & Bell Constr. Co., 356 Ridge Ave. Estimated cost $500,000. Steaming system will be installed.

Ia., Waterloo—The Rath Packing Co. awarded the contract for the construction of a 5 story, 90 x 100 ft. cold storage and refrigeration plant on Sycamore St., to G. W. Scales, 903 L. & S. Bldg., Waterloo, $76,118. Noted April 10.

Ky., Pineville—The Kentucky Utilities Co., M. E. T. Bldg., Louisville, awarded the contract for the foundation, sub-structure, etc., of a 15,000 kw. hydro-electric plant, 5 miles from here, on the Pine Mt. branch of the Louisville & Nashville R.R., to The Foundation Co. of America, 28 East Jackson Blvd., Chicago, Ill. Turbines, etc., to General Electric Co., Schenectady. Total estimated cost $2,000,000.

La., Plaquemine—The Mayor and Bd. of Aldermen awarded the general contract for the construction of an electric light and power plant, to the Hayden Construction Co., Pass Christian, Miss, $12,000; power plant equipment, Fairbanks Morse & Co., 608 Magazine St., New Orleans, $78,545; digging well, Gray Artesion Well Co., American Natl. Bank Bldg., Pensacola, Fla., $4,000; pipe, National Cast Iron Pipe Co., Tarrant City, Birmingham, Ala, $8,245; valves and hydrants, Columbian Iron Works, 811 Boyce St., Chattanooga, Tenn., $410.64. Noted April 10.

Minn., Virginia—The city awarded the contract for the enlargement of the central heating station and the extension of heating mains to the Range Contracting Co., 412 First Natl Bank Bldg., $66,975. Noted April 3.

New York—The Power Corp. of New York, Northern New York Trust Bldg., Watertown, awarded the contract for the construction of a power house and dam at Flat Rock to Burns Bros. & Haley, Inc., Watertown. Estimated cost about $800,000. Noted April 10.

Ore., Astoria—J. V. Neimi will build a 50 x 100 ft. addition to plant, by day labor. Estimated cost $10,000. Owner is in the market for ice making and refrigeration machinery.

Pa., Phila.—The La Trianon Hotel Co., c/o M. De Wilde, 1520 Spruce St., awarded the contract for the construction of a 26 story, 100 x 260 ft. hotel, to G. P. Pawling & Co., 1432 South Pennsylvania Sq., $7,000,000. Steam heating system will be installed.

Tenn., Memphis—The Security Building Co., c/o McKim, Mead & White, Archts., 101 Park Ave., New York, awarded the contract for the construction of a 12 story office building on Madison Ave., here, to E. M. Minter & Co., 115 Bway., New York. Estimated cost $700,000. Equipment detail not reported. Noted Jan. 23.

Va., Charlottesville—University of Virginia awarded the contract for a 4 story, wing for University of Virginia Hospital, to W. P. Thurston Co., Merchants National Bank Bldg., Richmond, $115,000. This is the first unit in expansion program calling for 14 new buildings at total cost of $3,000,000.

Wis., Milwaukee—The Milwaukee Elec. Ry. and Light Co., Public Service Bldg., awarded the contract for the construction of a 2 story 100 x 210 ft. turbine and boiler house at Lakeside to the Meredith Bros. Co., 1043 Kinnickinnic Ave. Estimated cost $1,000,000. Noted Aug. 29, 1922.

Wis., Port Wing — The Northern Wis. Hydro Electric Power Co. awarded the contract for the construction of a 60 x 95 ft. power house to the Jacobson Engineering Co., 533 Metropolitan Bldg., Minneapolis, Minn. Estimated cost $75,000. Power machinery, turbine, generator, etc., will be required. Noted April 10.

Wis., Rhinelander — The Rhinelander Electric Power Co., will build a 32 x 50 ft. power house, by day labor. Estimated cost $40,000. Contract for 1,000 kva. generator and 1,250 hp. waterwheel awarded to the Allis Chalmers Co., West Allis. Noted Mar. 27.

Wis., Sheboygan—The O. Kohl Estate, c/o W. C. Weeks, Engr., 720 Ontario Ave., awarded the contract for furnishing and installing steam heating plant and boiler in store and apartment building, to the Prange Geussenhainer Co., 8th and Wisconsin Sts. Noted April 17.

B. C., Elko—The East Kootnay Power Co., Ltd., Cranbrook, awarded the contract for the first unit of 50,000 kw. hydro-electric power plant as follows: two 7,500 hp. turbines to the Dominion Engineering Co.; two 6,000 kw. generators to the Canadian General Electric Co.; tunnel, 2,000 ft. long, to Winston Bros. Co., 801 Globe Bldg., Minneapolis, Minn. S. D. H. Pope, Elko, Engr.

B. C., South Vancouver—The British Columbia Electric Ry., 425 Carroll St., awarded contract for foundation and walls, for automatic rotary substation, Main and 34th Sts., capacity of plant 1,000 kw., a.c., 3 phase, 60 cycle to Robertson & Bendell, 850 Hastings St., W., $7,500; 1,000 kw. automatic rotary transformer and equipment to Canadian Westinghouse Co., 602 Hastings St., W. Engrs. est. $60,000. Noted Dec. 12.